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RECENT PERFORMANCES OF THE U. S. S. *OREGON*.

BY PASSED ASSISTANT ENGINEER CHARLES A. E. KING, U. S. N.

The U. S. S. *Oregon*, attached to the Pacific Station, was docked at the Naval Station at Puget Sound, State of Washington, on January 4th, 1898, and, having had the usual docking repairs made, her bottom cleaned and painted, and all outboard fittings examined and found in good condition, was floated on February 16, 1898.

What proved to be the most remarkable voyage in the history of battleships began at 6·10 A. M., on March 6, 1898, when the main engines, having been tried under steam, were reported ready to the Chief Engineer by P. A. Engineer C. N. Offley, U. S. N., who was the Engineer officer on duty at that time. The engines were worked by signals from deck from 6·40 to 6·50 A. M., when the signal was received "Ahead full speed." From that time until 8·30 P. M. on May 24th, when the engines were stopped and the *Oregon* anchored off Jupiter Inlet, Florida, this remarkable machinery, cared for and manipulated by an Engineer department whose perfect organization and rare ability stand pre-eminent, worked without a serious casualty.

The history of this voyage, as given in the steam log books, is a story of ceaseless vigil and painstaking care on the part of the Engineer personnel. Countless small defects, inseparable from such a run under steam, were detected and at once remedied, and no opportunity was lost to maintain the efficiency of the motive machinery and its dependencies by intelligent adjustments at the proper time. The devotion to duty of officers and men and the willing co-operation of all in striving to maintain the vessel's speed and efficiency merit the greatest praise.

Life below the protective deck of the *Oregon* after March 6, 1898, was a life of hardship and toil, a life spent in a heated atmosphere where the roaring of the furnaces and the leaping of the massive engines might well have afforded some excuse for confusion and lack of purpose among those whose days and nights were passed there. Not so, however. These men of the Engineer department rose equal to the emergency and went about their duty calmly, earnestly and with wonderful intelligence. The organization was perfect and the execution of the task set faultless. On more than one occasion when the labors of the men before the furnaces seemed to them to go for naught, and they felt all but discouraged because the steam would not "go up," the Engineer officers, discarding their uniforms, jumped among them, fed the furnaces with their own hands, and, by force of this example, so encouraged the firemen that, with cheers, they redoubled their efforts, and the good ship sped through the water at a faster pace. This is the spirit that imbued the men of the *Oregon*, and this the work that brought to a successful end the most remarkable run ever made by a battleship.

The voyage was made in eight stages, as follows:

1st. From Puget Sound Naval Station to San Francisco.
2d. From San Francisco to Callao.
3d. From Callao to Port Tamar in the Straits of Magellan.
4th. From Port Tamar to Punta Arenas.
5th. From Punta Arenas to Rio de Janeiro, Brazil.
6th. From Rio de Janeiro to Bahia, Brazil.
7th. From Bahia to Barbadoes.
8th. From Barbadoes to Jupiter Inlet, Florida.

The ship was coaled at Puget Sound Naval Station, San Francisco, Callao, Punta Arenas, Rio de Janeiro and Barbadoes. The kind of coal used during each run is given in the performance table below, as are also the distances run from port to port.

The complement of the Engineer department was as follows:

Chief Engineer R. W. Milligan, U. S. N.
Passed Assistant Engineer C. N. Offley, U. S. N.
Assistant Engineer J. M. Reeves, U. S. N.
Assistant Engineer Frank Lyon, U. S. N.
Naval Cadet, Engineer Division, H. N. Jenson, U. S. N.
Naval Cadet, Engineer Division, W. D. Leahy, U. S. N.

Chief machinists,	5
1st class machinists,	3
2d class machinists,	2
Yeoman,	1
Boilermaker,	1
Blacksmith,	1
Coppersmith,	1
Water tenders,	6
Oilers,	8
1st class firemen,	14
2d class firemen,	14
Coal passers,	40

A total of officers and enlisted men of 94. It is interesting to compare this number with the total Engineer force employed by the Union Iron Works upon the official trial trip of the *Oregon*, when the number on duty was 161 men.

The voyage may be considered to have ended when the ship dropped anchor at Jupiter Inlet on the night of May 24th, and the record given below closes at that time. Still further honor awaited this wonderful ship, however. At 3·57 in the morning of May 25th the engines moved ahead slowly and the *Oregon* began her journey to Key West, where she arrived the following day shortly after 7 A. M.

Ordinarily, after a run of more than 14,500 knots, a great many repairs would be found absolutely necessary even to a cruiser,

and several weeks would not be considered too long a time to spend in rehabilitating the engines and boilers of any ship after such extraordinary service. But the *Oregon* coaled, rapidly completed a few adjustments of machinery, repaired a few minor defects and at 1·04 in the morning of May 29th, less than three days after her arrival, steamed away from Key West to add her strength to that of our fleet off Santiago de Cuba.

Her part in the battle of July 3, 1898, which resulted in the annihilation of the Spanish fleet under Admiral Cervera, is now a matter of history. If any further evidence is needed than that already given of the qualities of the *Oregon*, and of her personnel, the following quotations will undoubtedly furnish it:

"The *Oregon*, steaming with amazing speed from the commencement of the action, took first place." (Official Report of Rear Admiral W. T. Sampson, U. S. N., upon the battle of July 3, 1898.)

"The fine speed of the *Oregon* enabled her to take a front position in the chase, and the *Cristobal Colon* did not give up until the *Oregon* had thrown a thirteen-inch shell beyond her. This performance adds to the already brilliant record of this fine battleship and speaks highly of the skill and care with which her admirable efficiency has been maintained during a service unprecedented in the history of vessels of her class." (Ibid.)

"The *Oregon*, having proved *vastly faster than the other* battleships, . . . continued westward in pursuit of the *Colon*." (Official report of Commodore W. S. Schley, U. S. N., upon the battle of July 3, 1898.)

"I cannot close this report without mentioning in high terms of praise the splendid conduct and support of Captain C. E. Clark of the *Oregon*. Her speed was wonderful and her accurate fire splendidly destructive." (Ibid.)

"The two remaining vessels were now some distance ahead, but our *speed had increased to sixteen knots*, and our fire . . soon sent . . the *Viscaya* to the shore in flames." (Official report of Captain C. E. Clark, U. S. N., commanding the *Oregon*, upon the battle of July 3, 1898.)

"As these vessels (the Spanish) were so much more heavily

armored than the *Brooklyn* they might have concentrated upon and overpowered her, and consequently I am persuaded that, but for the way her officers and the men of the *Oregon* steamed and steered the ship and fought and supplied her batteries the *Colon* and perhaps the *Viscaya*, would have escaped." (Ibid.)

"The *Oregon* was keeping up a steady fire and was coming up in the most glorious and gallant style, *outstripping all others.* It was an inspiriting sight to see this battleship, with a large white wave before her, and her smokestacks belching forth continued puffs from her forced draft. We were making fourteen knots at the time, and the *Oregon* came up off our starboard quarter at about six hundred yards and maintained her position, though we soon after increased our speed to fifteen knots, and just before the *Colon* surrendered were making nearly sixteen." (Official Report of Captain F. A. Cook, U. S. N., commanding the *Brooklyn*, upon the battle of July 3, 1898.)

The Engineer officers on board the *Oregon* during this memorable engagement, and their stations, were as follows:

Chief Engineer R. W. Milligan, in charge of machinery.

Passed Assistant Engineer C. N. Offley, starboard engine-room.

Assistant Engineer J. M. Reeves, port engine-room.

Assistant Engineer F. Lyon, in charge of fire-rooms.

Naval Cadet H. N. Jenson, after hydraulic pump-room.

Naval Cadet W. D. Leahy, forward hydraulic pump-room.

Acting Assistant Engineer T. C. Dunlap, starboard engine-room.

The number of enlisted men in the Engineer department was 114.

Thus we see that the *Oregon*, four and one-half months out of dock, with an Engineer complement of 121,* was able, almost immediately after a voyage of more than 15,000 miles, to go into battle and fight successfully, while making a speed of 16 knots per hour. Her contract trial speed was 16.791 knots per

* This number is an increase of 27 over those on board during the voyage from California to Florida; the additional officer and men having been ordered on board after the arrival at Key West, to meet the war conditions.

hour, and the Engineer complement at that time 161, as previously stated.

The record of this peerless battleship and the efficiency of her officers and crew stand unequaled in the history of the world's navies, and shed new luster upon the skill of American shipbuilders and mechanics, and upon the intelligence and devotion to duty of the personnel of the American Navy.

A table of performances is given on the opposite page.

U. S. S. *O*

Bunker capacity, 1,590 tons c

Date.	Hours.	Speed. Knots pr. hour.	Total coal expenditure for 24 hours. Tons.	Knots.		Coal endurance.		Months out of dock.	Wind	
				Per day.	Per ton of coal.	In days.	In knots.		Direc-tion.	
March 6–9, 1898.....	72.	11.48	69.74	275.57	3.95	22.7	6280.	$\frac{2}{3}$	11	
Mar. 19–Apr. 4, 1898...	375.	10.9656	61.80	263.744	4.267	25.7	6784.	1	6	
Apr. 7–16, 1898.....	213.6	11.935	88.73	286.45	3.288	17.9	5228.	$1\frac{2}{3}$	3	
Apr. 17, 1898, (8 A. M. to 5 P. M.)	9.	14.6	176.64	350.4	1.98	9.0	3148.	2	Var.	
Apr. 21–30, 1898.....	221.25	10.159	70.30	243.78	3.467	22.6	5512.	2	5	
May 5–8, 1898.....	74.25	10.09	74.85	242.16	3.234	21.2	4942.	$2\frac{2}{3}$	2	
May 10–17, 1898.....	193.25	11.544	77.00	276.77	3.594	20.6	5714.	$2\frac{2}{3}$	9	
May 19–24, 1898.....	141.5	11.773	81.14	282.55	3.482	19.5	5536.	3	9	

* Half t

Total knots of above performances.....	14,510.9
Total hours of above performances,.....	1,299.85
Total tons of coal used, above performances.....	4,009.38
Knots per hour (all runs).....	11.16
Knots per ton (all runs).....	3.61

ns of 43.5 cubic feet to the ton.

ind. Force.	Sea.	Boilers in use.	Kind and quality of coal.	Total knots logged.	Remarks.
4	S. to M.	3 main.	Comox; good.	826.7	Puget Sound to San Francisco.
3	S. to M.	3 main.	Comox; good.	4,112.1	San Francisco to Callao.
3	S. to M.	3 main.* 4 main.*	Cardiff; good.	2,549.4	Callao to Port Tamar.
2	S.	4 main.	Cardiff; good.	131.4	Port Tamar to Punta Arenas. Steaming through Strait of Magellan. Blowers in open fire-rooms. Av. I.H.P. = 6,450.
3	S. to M.	4 main.	Cardiff; good.	2,247.7	Punta Arenas to Rio de Janeiro. Following U. S. S. *Marietta* and suiting speed to hers.
3	S.	4 main.	English bituminous; fair.	749.7	From anchor off Rio to Bahia, Brazil.
3	S.	4 main.	English bituminous; fair.	2,228.0	Bahia to Barbadoes.
3	S.	4 main.	English and Welsh bituminous; fair.	1,665.9	Barbadoes to Jupiter Inlet, Florida.

alf time.

Greatest displacement, April 7..... 11,857 tons.
Least displacement, March 9..... 10,417 "

WATER-TUBE BOILERS.

By Passed Assistant Engineer J. Alvah Scott, U. S. Navy.

[A discussion of Mr. Darwin Almy's paper on this subject in the February number.]

The requirements necessary in water-tube boilers will vary widely in accordance with their uses; but they can be divided into two classes—the torpedo-boat boiler and the commercial boiler. The class we have most prominently before us to-day is the torpedo-boat boiler, and this boiler, on account of the very severe demands upon it, must be of comparatively high first cost, expensive maintenance and short life.

The first cost is great on account of having to put so large a boiler in so little space. Small bent tubes have to be resorted to, and the expense attached to bending these tubes is necessarily a large one, compared with the cost of a boiler with straight tubes.

The cost of maintenance is high, provided the boiler is kept in condition for any length of time, as every few years they require retubing, and, as the tubes form a very large item in the cost, it brings the maintenance very high.

The boilers are short lived, as the life of the boiler is practically the life of the tubes, which last on an average about six years, where they are of good iron, of fair thickness, and are well cared for; yet in some cases such boilers have been used eight years without retubing, while in many cases they have given out in two or three years.

These boilers need the most attention when they are laid up, for it is under this condition that the exterior of the tubes is exposed to more or less moisture, which, together with the deposits on the tubes from the products of the furnace, cause severe corrosion.

There is, of course, more or less interior corrosion taking place at all times; but in my experience of eight years with this kind of boiler, I have found this to be comparatively small, the worst of it taking place in such tubes as delivered into the steam drums above the water line, in their upper part. This, I have concluded, was due to the fact that while the boiler was not running but standing with water in it this portion of the tubes was exposed to the air, which, together with the natural moisture from the water, produced the condition of "between wind and water," and caused corrosion. There have, of course, been cases where the tubes failed by excessive interior corrosion in other localities, but in most cases this was due to galvanic action.

The interior corrosion can easily be guarded against, or rather very much reduced, by not allowing the boiler to stand any length of time out of use with water in it. It is advisable to blow out the boiler completely, and while it is still warm remove the heads or hand and man-hole plates and allow the tubes and drums to dry out. This should be done even if the boiler is only going to be out of use for a few days; for while very little damage would be done in that time, frequent repetition of that practice would have serious results.

If a boiler is to be laid up for any length of time, and is so constructed that when filled with water no air remains in the tubes, it is good practice to fill them with water saturated with lime, but, in most boilers where the tubes deliver above the water line in the upper drum, it is impossible to free all parts of the tubes of air, and in such cases it is best to dry the boiler out and place unslaked lime in each drum; for while this part of the tube contains air with so much surrounding moisture, corrosion is sure to take place to a marked degree if left for any length of time. In cases where the boilers are laid up dry, the drum heads should be replaced.

As for the exterior corrosion, too much attention cannot be given to it, and every precaution should be taken to check it. The part of the tubes in the vicinity of the stack is subject to the greatest exposure and is about the first to give out; it is evident, therefore, that whenever the fire is drawn, the stack

should be covered to prevent moisture from gathering on these tubes, and this should be done as soon as the fire is drawn, and the cover should not be taken off until ready to start fires again.

When the boiler is to be laid up for any considerable length of time the grate should be covered with unslaked lime, which will absorb any moisture that may be in the furnace or among the tubes.

I have considered the elements which tend to shorten the life of water-tube boilers and the precautions necessary for their care, as they apply to all, regardless of the type of boiler, with very little variation.

In all water-tube boilers, and especially in those that are forced to the extreme, as in torpedo-boat boilers, great care must be exercised regarding the circulation of the water in the boiler, the circulation of the gases of combustion, and the provision of a sufficiently large combustion space to allow the gases and air to properly mix and combine. This latter frequently necessitates the admission of air above the grates, but in torpedo-boat boilers, there is not sufficient space at disposal for so large a combustion space, and in consequence final combustion frequently takes place among the tubes. This last point will be discussed later.

Regarding the circulation of the water, it is hardly necessary to say that a return circulation must be provided for. In extreme forced-draft boilers this provision can not be too well taken care of, and even though it is possible for circulation to take place in the steaming cluster of tubes, it is very liable to be sluggish in its action, and outside downcomers should be provided.

I will take occasion to quote Mr. J. A. Normand on circulation, from his paper on water-tube boilers, read at the thirty-sixth session of the Institute of Naval Architects, London, June 13, 1895.

"In a paper read last year at the Southampton meeting, Mr. Thornycroft described some very interesting trials made on two boilers, differing only in this—that in one of them the heating tubes rose above the level of the water in the upper reservoir, whereas, in the other one, the upper ends of the tubes were under water. The difference of pressure between the upper and lower

reservoir was found to be greater in the second than in the first case.

"The great engineer of Chiswick concluded from this fact that, since the difference of pressure reduces the circulation (which is quite undeniable), the circulation is greater with tubes rising above the water level. With all due deference, may I be allowed to state that I draw from these trials entirely opposite conclusions?

"The dimensions of the outside return tubes being similar in both cases, and admitting that the total return of water takes place by these tubes, and not partially through some of the heating tubes less exposed to the fire (which does not seem to be a very reliable arrangement), it is clear that the quantity of water which goes down through the return tubes will be proportional to the square root of the difference of pressure between both reservoirs. Now, this quantity of water is, by hypothesis, exactly equal to the ascending water, so that it is, according to the trials, greater in the boiler when the upper end of the tubes is under water.

"This conclusion is in accordance with the following probable theory, that the head of water which causes the circulation in a tube rising above the water must be reduced by a height equal to that of the tube above the water level, due allowance being made for the smaller density of the fluid. The under-water arrangement does not, perhaps, allow of so great a heating surface for a given encumbrance, but it offers the further advantage that no 'steam chamber' can exist in the upper part of the tubes.

"I have already alluded to laboratory experiments according to which the co-efficient of the transmission of heat varies from one to five, according as the water to be heated is quite stationary or in rapid motion. Particulars may be found in the 'Traité de Physique Industrielle,' by Ser, Volume I, page 225, &c. This is easily accounted for by this fact, that water is a very bad conductor of heat, and can be heated only by putting all the particles successively in contact with the heating surface.

"Although the actual conditions of a boiler are very different from those of the experiments, especially as regards the tempera-

ture of the heating fluid, it is not less true that active circulation in boilers is most favorable to vaporization.

"This explains how the advantage to be derived from the use of feed heaters is always superior to that which results from the economy in the units of heat saved. This is especially to be noticed with Mr. Kirkaldy's feed heater. In this apparatus steam taken from the boiler heats the feed before its introduction into the boiler. The result is evidently to equalize, in a great measure, the temperature of the water and steam contained in the boiler with no apparent, though with an undeniable economy. The phenomenon may be explained as follows:

"When the water enters the heating tubes it travels without boiling through a certain length of those tubes; the lower its temperature is below that of steam, the longer this distance; and, since the circulation is caused by the development of bubbles in the tubes, the intensity of the circulation is reduced as this difference of temperature increases.

"For the last two years I have obtained the same result in the most simple manner by introducing the feed in the steam space under the form of spray, as far as possible from that part where steam is taken for the engines. The feed being already heated by steam having done work in the H.P. and M.P. cylinders, there is scarcely any difference of temperature between the water and the steam in the boiler. As soon as the water enters the heating tubes, bubbles of steam are produced, and the circulation is increased to such a rate that the temperature of the tube is not higher than with cold feed.

"This mode of introducing the feed, which has the further advantage of depositing the calcareous salts in the form of powder, when using sea water, requires some very simple but special arrangement, to avoid shocks in the feed pipes."

The downcomers are not the only requirement for rapid circulation, as the closeness with which the tubes approach the vertical, and their proportion of diameter, or rather internal area, to length that is exposed to the products of combustion have a great deal to do with it; for where the tube is small in diameter and of excessive exposed length, the circulation is not only

sluggish, but the upper portion is liable to be filled with steam, making it dangerous.

Of course, in boilers where so much power is required in so little space and weight, large diameter tubes are not permissible, as they not only take up considerable room, but contain a great deal of weight in water, so we are driven to the smallest tube that stands the driving without exposing steam-covered surface to the fire.

In the general run of successful torpedo-boat boilers of to-day, this diameter was found to be from $1\frac{1}{8}$ inches to $1\frac{1}{4}$ inches on a furnace-exposed length of 5 to 6 feet. The furnace tube is the one that determines the proportions necessary, but for mechanical reasons, all the tubes are of about the same diameter; in some cases $\frac{1}{8}$ inch less.

I may say, however, contrary to Mr. Almy's statement, that tubes of large diameter are not seriously objectionable, otherwise than that they take up considerable room for a given unit, and contain a large quantity of water, necessarily weighty, and probably the most serious objection to their use is the damage liable to be done in case of one giving way.

Probably the most essential requirement for rapid circulation is the full and unobstructed opening of the end of every tube where it enters the upper drum.

The question of the expansion of the tubes is one on which almost all authorities disagree, but it is evident that the faster the circulation, the nearer the temperature of the tube is to that of the water, while where the circulation is sluggish and the contents of the tube are formed largely of steam, overheating is the result, and consequently excessive expansion.

In boilers that are to receive excessive forcing, there is more or less expansion due to the difference between the temperature of the tubes and their contents, especially in the vicinity of the furnace, and bent tubes are a necessity; while in boilers that are only subjected to moderate driving, where there are ample provisions for circulation, straight tubes are permissible, as will be shown later on.

The circulation of the gases of combustion among the boiler

tubes has a very decided bearing upon the efficiency of the heating surface, and all boilers should be so constructed as to form flues to compel the gases to pass over as near the entire heating surface as possible.

In order to do this it is necessary to contract the area of these flues so that the gases are compelled to spread over the whole surface, for if the area is much larger than is necessary, the gases will take the shortest possible course to the stack, and pass over only a portion of the heating surface..

It is well, where possible, to cause the gases to impinge on the tubes rather than run in line with them; for in the former case, considering combustion alone, the gases are more liable to be properly mixed with whatever air may be present, and there can be no disputing the fact that where the gases do impinge the economy of the surface is higher than when the gases travel parallel with it.

In Mr. Almy's reference to the size of the grate in Scotch boilers, he evidently considers that their sizes were determined upon as the ideal grate, while the conditions are quite the reverse; for in that case the grates were limited to what the mechanical conditions would permit, and, on account of the small height of furnace, it was impossible to properly fire a long grate; but in water-tube boilers the conditions are very different, as furnaces of good height can be had, which enables long grates to be fired as easily and as well as those of moderate length in Scotch boilers.

Large grate areas can, with systematic and careful firing, be efficiently maintained. In torpedo-boat boilers, grates of over fifty square feet area and about eight feet in length have been fired with very good economy, even under severe forced draft, and the same can be expected of grates of even greater dimensions, as it is only a matter of the experience and skill of the firemen, provided the boiler is designed to produce an approximately even rate of combustion throughout the grate.

There are many apparently small things in the fitting of the furnace which tend to success, such as the system of firing, the

way in which the gases leave the furnace, their manner of entering the tube flues, and the admission of air above the grates.

Regarding the fire bars, it is necessary that they should be deep but quite thin, so that they will not have much metal to take up the heat of the burning coal, and so that the cool air passing between them will keep them sufficiently cool to endure very severe forcing. It is very important that no clinker be allowed to form, for just as soon as it does, the passage of air is cut off, locally, and the bars become overheated and burn out.

It is also very important that the air space should be quite large, that is, with bars of $\frac{5}{16}$-inch thickness on the upper side, there should be from $\frac{3}{4}$ to 1 inch space between them; the latter is the best with selected soft coal of good quality, but the former would be probably better for general running with commercial coal, under which circumstances the bars could be thicker; but as speed is the first essential in a torpedo boat it is best to make everything for the full speed and sacrifice cruising conditions.

In firing it is necessary to keep a light, even fire of say about nine inches in thickness, and fire frequently and in small quantities, and, should the grate show a tendency to burn more coal on one part than on another, favor the slower burning part with a thinner fire, so as to equalize it as much as possible. This, however, can only be done to a small degree, as I will show in describing the effect of the location of the flue openings upon the performance of the grate.

In the boilers of the United States torpedo boats *Foote*, *Rodgers* and *Winslow*, which are of the Mosher type, the gases of combustion enter the tube flues from the back portion of the furnace, naturally inducing the draft to cut through that end of the grate. This action, together with the tendency of the air in entering the ash pit to rush to the back end, causes the fire in the back of the grate to burn more freely than in the front end.

This was very noticable on the trials of these boats, and it can be safely said that there were portions of the backs of furnaces where there was fully twice as much coal burned as on the average of the grate. The fire in the front end was, however, by no means dead; it was a very good fire, but the intensity of the

back end was terrific, and it was only with the greatest skill on the part of Chief Engineer Coleman's firemen that holes in this part of the fire were prevented, and they deserve great credit, as the most of their firing had to be done at long range, a fact that any one who has had to do with long grates will appreciate.

In the Thornycroft boiler this trouble does not exist to such a marked degree, but it is still there; while in the Normand boiler the conditions producing this defect have been eliminated, and, in fact, the tendency in that boiler is to burn more coal in the front end of the furnace, as the openings to the flues are located at the front or door end, which more than counteracts the tendency of the air to rush to the back end of the ashpit.

This, I think, is one of the reasons for the very high combustion per unit of grate surface in the Normand boilers, for it is clear that if the heavy firing of the back end of the furnace can be overcome and combustion occur more evenly with a tendency to the front end, more can be done without additional exertion on the part of the firemen or extra stress on the bars; but as the limit of our firing is the endurance of the grates and not of the men, and as it is evident that all parts of the grate can stand as much as the part most severely taxed, then in the case of the torpedo boats *Foote*, *Rodgers* and *Winslow*, their grates would have afforded about twice the mean rate of combustion if it took place on all parts equally.

As for admitting air above the grate bars, experiments which have been carried out in almost all parts of the world have shown decided advantages in economy of the furnace, but the gains have been more decided in water-tube boilers than in others, and on account of the small combustion space allowable for the enormous amount of combustion taking place in a torpedo boat boiler, this is made necessary for good results where the higher rates are to be used with any economy.

The best available way, in torpedo boats, for admitting this air is through the furnace ends, at both if possible; but where it can be admitted only at one end, it is best to have it at the end where the gases enter the flue, should the flue openings be at one end. This is apparent from the fact that full combustion

has not had a chance to take place in the furnace, and must finish while the gases are among the tubes, and the air when admitted through this end of the furnace is best mixed with the gases as they leave the furnace.

Some authorities claim that delivering the air in among the tubes gives better results, but there is some chance of the gases falling sufficiently in temperature, before they are thoroughly mixed, to prevent complete combustion.

The mixture is not liable to be so good if the air is admitted through the opposite end of the furnace from the flue opening, probably more from a mechanical consideration than anything else, as it does not become so well mixed in with the gases, apparently keeping in distinct bodies, and not reaching all the products.

This, of course, will apply to some extent with the air entering from the flue-opening end, but by no means to such a marked degree, and the safest way is to provide air inlets in both ends.

In considering water-tube boilers for commercial marine work, such as steam ships, steam boats, and war vessels other than torpedo boats, there is one very important point that will always remain against them, and that is their entire disablement caused by the giving way of a tube, compelling the extinguishing of fires and emptying of the boiler. Nevertheless the constant demands for lighter machinery weights will soon force this class of vessels to the use of water-tube boilers, should a successful one be introduced; but it is safe to say that there is not a single water-tube boiler on the market to-day that can fulfil this want.

In Mr. Almy's paper, that gentlemen lays down some stiff and rigid rules as the requirements for a successful boiler, and at the same time declares that screwed joints are not objectionable in the fire. On this point I take decided issue with him, and I may say that any one who has had experience with seams or joints of any kind in the furnace will appreciate the trouble and annoyance they cause, and screwed joints may easily be set down among the worst. While this has been found to be the case under moderate rates of combustion, it is well known that it is greatly increased with the increased rate of combustion.

Regarding Mr. Almy's requirements, it may be said that he lays undue stress upon the importance of being able to remove any one tube without disturbing any other tube or the casing.

Now, in a water-tube boiler, this is not only unnecessary, but can only be accomplished by resorting to unmechanical and unnecessary means. The mere giving out of a single tube or even several tubes in a boiler is of little account, as they form a very small proportion of the total, and they can be easily plugged with tap plugs until such time as retubing, or partial retubing, is necessary, and it is safe to say that as water-tube boilers become more used, the plugging system will become a necessity and, sooner or later, a universal practice. This applies to torpedo-boat boilers as well.

I will state what my experience has suggested as the probable requirements which a water-tube boiler will have to fulfil for commercial service.

Not only on account of first cost, but mainly on account of second cost, or cost of maintenance, it is necessary that such a boiler should be composed of straight tubes; and, again, as it is possible to clean such tubes, there would be less trouble from the use of impure water.

It is, however, necessary, in order to extract the heat from the products of combustion, to arrange the passage of the gases so that they are conveyed through flues and do not short-circuit among the tubes. This is as important in a boiler of this type as in the torpedo-boat type, for in the latter, the efficiency of the surface must always be high, while the commercial boiler must show high economy of fuel.

In reference to Mr. Ward's statement regarding the passage of the gases among the tubes, that it was only the difference between their fast passage over a small area or their slow passage over a large area, I will say that in the fast passage, the area being contracted, there is no choice of the portion of the area through which short-circuiting could take place, so the whole area will be covered, while with the slow passage over the large area there is every probability of short-circuiting on account of the excessive area.

I will again take the liberty to quote from the paper by Mr. Normand (already referred to) on this question, as follows:

"With a given capacity of boiler, the section of passage may be very great and the length of travel very small, or the section may be very small and the travel very long, with all intermediate proportions between these extreme limits.

"In the first case the draft is good, but the heating surface is very seldom thoroughly utilized. In the second case a good air pressure is necessary, but the economic duty is better, because the hot gases are obliged to heat the whole of the heating surface, and because the transmission of heat increases with the agitation of gases, as it does in the case of water. This was proved a great many years ago by some most important trials made in France by Mr. Geoffrey, of the Northern Railway of France, on a locomotive boiler. (For details, see Ser, Volume I, page 564.) The evaporation was measured, first with all tubes open, and second with half the tubes only. In the last case, notwithstanding the enormous reduction of heating surface, the evaporation per pound of coal remained the same, with this difference only, that a greater air pressure was necessary. The conclusion to be derived is that the section for the passage of the hot gases should be reduced, and their travel lengthened as much as is consistent with the draft available."

In order to accomplish this result, it may be necessary to resort to placing fire tiles or some other fire resisting material among the tubes in order to form the flue walls. These tiles or their substitute should be easily removable to allow for cleaning the tubes externally, and for replacing the walls should they burn out or become destroyed from other reasons.

It is just as important in the commercial boiler to provide outside downcomers for return circulation as in the torpedo-boat boiler, but the size need not be so great proportionally, as the moderate steaming of the boiler will not cause so great a volume of circulation as would be caused by the intense evaporation required in the torpedo boat boiler.

In order that the circulation shall not be choked up, every tube in the boiler should have a clear opening into the upper

chamber, of its full diameter, and not have several tubes forming a cluster, with their contents delivering in common through one tube into the upper drum, as in several boilers in use to-day. It is also of great importance for the best results that the tubes should closely approach the vertical, as in this case the steam bubbles formed in the tubes are less liable to cling to the surface and the circulation is much more rapid, keeping the surface better covered with water and thereby absorbing heat, and increasing the power and economy of the boiler.

In the firing of these boilers, heavier fires are permissible, and very good results will be obtained from a 12-inch fire, especially if air be admitted above the grate bars. Complete combustion must take place in the furnace, and a combustion chamber of sufficient size must be provided for it, as it will be more perfect than when one depends on completing combustion among the tubes. Inter-tube combustion is unavoidable in torpedo-boat boilers where space is at such a premium, but in a boiler for commercial purposes, where economy is the all important factor, space must be taken to provide for the necessities.

It is also of great importance in a commercial boiler to have ample steam space, even though steam domes have to be resorted to.

Regarding the system of draft permissible with water-tube boilers, it may be said that, as a properly designed water-tube boiler can withstand the effects of forced draft with practically no injury, it is a waste of good space and the carrying of an unnecessary amount of weight to consider natural draft; while considering the best form of forced draft, it is well to remember that it is a practical impossibility to produce a boiler casing that will remain tight, and therefore where the closed ashpit draft is used, there is considerable gas leakage, which is a source of constant annoyance and danger to the firemen, for where ashpit drafts have been fitted to water-tube boilers it has been quite a common occurrence to have those in the fire room overcome by the gas; this is especially so where intense forcing is used. In this case I speak from personal experience, and a very unpleasant one at that.

We have two other popular systems of forced draft now in use with cylindrical, and one of the systems with water-tube boilers, which overcome this trouble and give satisfaction; one is the closed fire-room system, and the other the induced exhaust system, of which the Ellis & Eaves system is the most popular. On torpedo boats the closed fire-room system is almost always used, it being a mechanical necessity, but in larger vessels either can be used, and there is no doubt that induced draft could be applied to water-tube boilers with as good results as those shown on cylindrical boilers, as suggested in the discussion by Passed Assistant Engineer Emil Theiss, U. S. N.

The care of a commercial boiler is as important as in the case of a torpedo-boat boiler, and about the same precautions will be required.

EXPERIMENTS ON THE COMPRESSION OF STEAM IN THE CLEARANCE SPACE.

By Prof. M. Dwelshauvers-Dery.*

[Translated for "Power," and reprinted from that Journal by permission.]

I.

Is it economical to close the exhaust valve before the end of the return stroke as is done by the link motion, and in single-valve engines?

This question, which has long been discussed both in theory and practice, and has several times been summarily dismissed as settled, has not to our knowledge been made the object of a complete experimental research, methodically conducted, although certainly, from both a theoretical and practical point of view, its importance is incontestable.

Well conducted experiments on final compression will suffice to demonstrate that in ordinary engines, of which the clearance space does not contain irregularities which can form depositories for the collection of water, there is nothing but steam behind the piston at the moment the exhaust valve closes. In fact, certain phenomena revealed by these experiments would be inexplicable if there remained in the cylinder an appreciable quantity of water.

Many scientific experimenters, among whom we may cite MM. Marcel Deprez and Bauschinger, expect from compression a considerable advantage. In a remarkable article published in the "Revue Universelle des Mines," † M. Marcel Deprez writes as follows: "Compression augments very notably the work of counter-pressure developed during the return stroke, and it is

* "Revue de Mécanique," Paris, October, 1897.

† Tome XXXVI, page 185, *et seq.*, 1874.

in this respect that practical engineers criticise the distribution of the simple slide valve. With this idea in mind I determined upon a series of exhaustive experiments upon compression, and will undertake to demonstrate in accordance with the results of calculation and with observed facts, not only that compression is not detrimental, but that it is indispensable for the attainment of the maximum efficiency."

This proposition has already been enunciated by Professor Zeuner in his Traité de la Théorie Mécanique de la Chaleur (1869), and by M. Dwelshauvers in the "Revue Universelle des Mines," but M. Deprez depends for his demonstration on the theorems of thermodynamics, and the second assumes that the adiabatic line, which represents the line of expansion or compression of steam, is represented by the formula

$$\frac{p}{p^o} = \left(\frac{v^o}{v}\right)^m.$$

I propose to offer an entirely new demonstration which depends upon a single hypothesis, that of the identity of the laws of expansion and compression.

The demonstration of M. Marcel Deprez, like that of M. Zeuner and our own, does not take into account the action of the cylinder walls, but M. Marcel Deprez adds:

"During the period of exhaust the cylinder is in communication with the atmosphere or the condenser and subject to a comparatively low temperature, the more detrimental in that it affects precisely the portion which must be reheated when it is brought into contact with the steam from the boiler when admission succeeds the exhaust. There results a condensation, often considerable, during the period of admission, and this is one of the reasons that the consumption of steam is always greater than that calculated from the volume generated. This excess of steam consumption is often placed to the account of entrained water, but this explanation would not in most cases suffice to account for the considerable excess of the real over the theoretical consumption, especially when all precautions are taken to provide the engine with dry steam. It is endeavored

to evade this source of loss by the use of the steam jacket, which maintains the cylinder at a mean temperature nearly approaching that of the boiler, but the steam jacket has many disadvantages, of which the most apparent are that it is costly and cumbersome.* I do not intend to enter here into an exhaustive examination of the rôle of the steam jacket; it is an obscure question and one upon which scientists and engineers are far from being in accord. The condensation which takes place during the period of admission† can be entirely prevented by the use of compression, which reheats the walls of the cylinder and brings them to a temperature nearly equal to that of the boiler, and which may even exceed this temperature. It is, in fact, established that the vapor of water, even when it contains some moisture at the commencement of compression, may be considerably superheated after it has been compressed. This is a result which has been placed beyond doubt by thermodynamics and our own experiments.

"It had for a long time been noticed that on diagrams taken from locomotives, the pressure at the end of compression seemed to exceed that of the boiler by a considerable quantity (sometimes one or two atmospheres) when the diagrams were taken at high speed and low initial pressure. This has been attributed to the momentum of the piston of the indicator, but I designed some years since (in 1868) an indicator which was exempt from the effects of inertia and momentum, diagrams from which presented the same appearance and which have enabled me to establish in a manner absolutely certain, that the compression can carry the steam to a pressure superior to that of the boiler, even in condensing engines. I will cite as an example, a non-condensing engine in which, by reason of the small clearance, the compression carried the pressure above six atmospheres, while there were but four atmospheres in the boiler. I will cite also a condensing engine furnished with a steam jacket, which

* Imbued with the same ideas as M. Marcel Deprez, we added in 1873 that compression had the advantage to reheat even the face of the piston, which the steam jacket could not reach.

† Generally referred to as initial condensation.

had a pressure at the end of compression exceeding by about an atmosphere that of the boiler. This engine developed 22 horse power by the brake. I cut out a portion of the inside lap and the diagram showed a great reduction in the compression. At the same time the power developed by the brake, under conditions otherwise equal, rose to 35 horse power. In view of such an increase of power due to the reduction of the compression, my first thought was that the latter was very detrimental, and that the economical duty would increase in the same proportion as the power, since the admission had not been varied and since also the clearance spaces were very small, about $2\frac{1}{2}$ per cent. To my great surprise I found the contrary to be the case. Notwithstanding the conditions of this engine were such that compression appeared to have no reason to be effective, since the engine was condensing, furnished with a steam jacket and with clearance spaces reduced to a minimum, the reduction of the compression had for effect the increase of the consumption of combustible per horse power per hour.

"Professor Bauschinger undertook in 1870 a long series of experiments on the locomotives of one of the railroads of Bavaria. A certain number of the machines which were employed in his experiments had been provided with the Meyer double valve, and the compression was practically nothing, while the other engines were furnished with the Stephenson link motion. These two classes of machines performed the same service, and their consumption of steam and of combustible per horse power and per hour was 16.98 kilos (37.4 pounds) in the engines furnished with the Meyer valve, and 13.83 kilos (30.5 pounds) in those which employed the link motion. The consumption of combustible was in the same ratio, and all the machines had practically the same boilers and the same cylinders. The machines with the Meyer valve required 22 per cent. more steam than those with the link motion, and the result can be attributed to nothing except compression. This is the conclusion drawn from these experiments by Professor Bauschinger, himself, who took from these locomotives a great number of diagrams with the Richards indicator."

II.

That which has most contributed to the belief that compression is economical, is the theorem enunciated and demonstrated by M. Zeuner which elicited the admiration of Hirn and Hallauer, and which the latter even believed to be confirmed by one of his experiments. The theory of Zeuner may be stated as follows:

With complete expansion, complete compression entirely annuls the detrimental effect of the clearance space.

By complete expansion is meant an expansion which lowers the pressure to that of the counter pressure, and by complete compression, a compression which brings the pressure of the steam confined in the cylinder at the time of the closing of the exhaust valve up to the initial pressure of the steam.

It is to be remarked, first, that this property of complete compression would be general, without restriction, independent of the extent of the clearance as well as of the piston speed. This consideration of itself would be sufficient to involve its correctness in doubt.

M. Zeuner has published a mathematical demonstration of his theorem in which he does not consider the modifying action of the cylinder walls. We have just seen that M. Marcel Deprez has presented another demonstration of the same case, and that he considers the action of the walls to be favorable to the economy of compression. In 1873 the writer published a graphic demonstration of the same case, and arguments such as those which M. Deprez considers of such importance led us to believe that the theory would be confirmed in practice. There still rested with us, however, a doubt which we sought to resolve by writing to Hirn, and thus commenced relations which ended in our friendship, but the question remained without experimental solution.

Our graphic demonstration of 1872 will throw some light on that which follows. Like that of M. Marcel Deprez, it requires but one hypothesis, namely, that the law of compression is the same as that of expansion, and for simplicity we will suppose that the expansion and compression follow the law of Mariotte.

Let Fig. 1 be an indicator diagram $A\,D\,E\,C\,A$, from a cylinder without clearance, into which is admitted a charge of steam AD of say 3 units volume and at the pressure of 4 atmospheres. This is expanded to a pressure of 1 atmosphere, represented by $e\,E$, equal to the counter pressure and then exhausted at that constant counter pressure represented by the horizontal line $E\,C$. The initial pressure $d\,D$ being four times the counter pressure, the volume at the end of the expansion represented by $C\,E$ is four times the volume $A\,D$ at the commencement, that is to say, 4×3 units or 12 units. The work developed in a cylinder without clearance at the expense of a volume of steam represented by $A\,D$ or 3 units is proportional to the area of the diagram $A\,D\,E\,C\,A$.

Suppose now that the cylinder had a clearance space of $O'\,O\,B\,A$ equal to $\frac{1}{6}$ of the volume of the live steam $A\,D$, that is to say, to $\frac{1}{2}$ unit, and that at the commencement of the stroke the steam which fills the clearance space has a pressure of four atmospheres like that which is admitted. Then the volume of steam present in the cylinder at the end of admission D and at a pressure of four atmospheres would be $3\frac{1}{2}$ units and would be represented by BD, and an expansion sufficient to lower the pressure to one atmosphere would increase the volume to $4 \times 3\frac{1}{2}$ units or 14 units, which would be represented by $F\,E'$. The volume generated by the piston on its return stroke would be therefore $E'\,C$, $13\frac{1}{2}$ units, but the exhaust valve would close when there was still to be generated a volume of $1\frac{1}{2}$ units, that is to say, the steam at a pressure of one atmosphere having a volume of 4 half units would be compressed to a volume of $\frac{1}{2}$ unit and to a pressure of four atmospheres by a complete compression. In this case the indicator diagram will be composed of two horizontals $A\,D$ and $C'\,E'$ and of the two hyperbolic arcs $D\,E'$ and $C'\,A$, having for common asymptotes $O'\,B$ and $O\,e'$, and the work developed in the second case at an expense of $A\,D$ or 3 units volume of steam will be proportional to the area of the diagram $A\,D\,E'\,C'\,A$. It is evident that this area is equal to that of $A\,D\,E\,C\,A$, for the two curvilinear triangles $C\,A\,C'\,C$ and

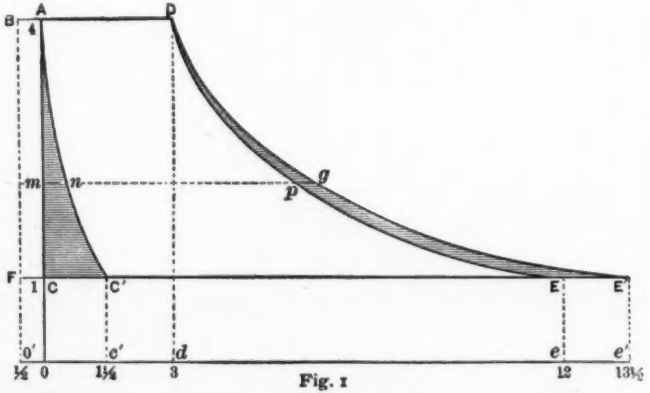


Fig. 1

EDE'E having the same height and an equal width upon any horizontal ordinate as *mm* and *pg* must have the same area.

III.

Such is the principle which it is necessary to verify experimentally and which is of capital importance, since, if one can by a complete compression annul the detrimental effect of the clearance, whatever its volume and whatever the velocity of the engine, the engine builder is in possession of a simple means to economize steam and will not be obliged to exercise his ingenuity in reducing the clearance.

Since 1873, therefore, we had expressed a desire for that experimental verification, but lacking the means and not having at our disposition an experimental engine, we addressed ourselves to Hirn, who had made the engine of Logelbach famous by his work and his researches. Unhappily that machine was occupied in an industrial service and did not lend itself to great compression. Hallauer, the right arm of Hirn, endeavored to satisfy us by experimenting on a compound engine, and he arrived at a verification of Zeuner's theorem, but indirectly and by means of calculations and suppositions which did not command our confidence. Our doubts were not dissipated, but, influenced by the opinions of so many authorities, we believed that the correctness of the theory of Zeuner would not be materially affected in practice by the action of the cylinder walls, assuring ourselves that the compression, having for effect the reheating of the metal enclosing the live steam admitted, would have a still more energetic action than the jacket which could not affect the head of the piston, which surface forms at the commencement of admission nearly one-half of the enclosing surface. With a complete compression, the clearance steam having the same pressure as that of admission has also the same temperature, and the enclosing walls having the same temperature as the steam in contact with them, the partial condensation of the vapor coming from the boiler would be considerably reduced, since it had to heat only that portion of the cylindrical surface uncovered

by the piston during the admission. The *initial condensation*, that is to say, that which is produced during admission, would, therefore, be considerably diminished. We must say, even now, that on this point our experiments have fully confirmed these views. We had not, however, foreseen at what price this result would be obtained.

Hirn expressed doubts that his machine was unable to satisfy. It became our earnest desire to be possessed in a laboratory among instruments of precision of an experimental engine which was not constrained to any industrial work, adapted to tests, a machine of precision and sufficiently flexible to be adjusted to all degrees of expansion and compression however arbitrarily chosen. To create such a laboratory adapted to the solution of this and many other such questions became our dream, encouraged by Hirn. It is somewhat surprising that it was not realized until after twenty-four years. Our excuse is that we had not obtained the experimental engine until after eleven years of continued quest. It required nine years to obtain the laboratory building and to instal the machine and three years to attain a satisfactory precision in delicate tests. To-day the engine tests made in our laboratory are conducted in a manner to inspire confidence in the results attained.

IV.

We consider none of our tests worthy of consideration that do not accord with the equations of Hirn. On an average we are able to work within one-half of one per cent. of error, but there is a stumbling block, especially when the engine is working under a light load. That is the value of the heat lost by external radiation, which we cannot determine exactly, no other than by a number of tests made under similar conditions, because this factor, sometimes very important, varies with the work of the engine. In all tests on compression we have encountered some difficulties from this cause. The lagging of the cylinder has been changed. We assume as a basis of calculation that the external radiation is in proportion to the duration of the stroke,

which, however, is not true except when the velocity is sensibly the same in all tests. If the velocity is raised, for example, from 45 to 60 revolutions per minute, the external radiation per second, when the steam jacket is not in use, varies sensibly. The external temperature has also an influence, on account of which we have considered it necessary to keep the entire laboratory closed, notwithstanding the suffocating heat, and to transform it into a sort of a vast calorimeter, in order to avoid some of the causes of error of which we would not be able to render an exact account.

By close attention to these details we attained a control of our apparatus which enabled us to obtain consistent results in experiments made upon a large scale. In all respects we have taken the precautions necessary to obtain the most rigorous exactitude as well in the calibration as in the observation of the instruments and apparatus.

The regulation of the steam distribution has been the object of our most careful attention. We employed a scale of the length of the stroke, 60 centimeters, over which passes back and forth an index attached to the crosshead. The scale is divided into a thousand equal parts of .6 of a millimeter (.024 of an inch) each. One can, with the naked eye, read easily to a half division, and with the vernier to the tenth of a division. By means of this scale the piston may be placed in any given position with a maximum possible error of .3 of a millimeter (about .01 of an inch), or the position occupied by the piston at a given moment may be determined with the same precision. By means of this scale, also, we are able to determine, at least to the tenth of a millimeter, the coincidence of the edge of the valve with that of the port which the valve is about to open or close.

After having chosen an average diagram we traced and measured by a vernier, reading to tenths of millimeters, all the ordinates necessary to calculate the areas and the work accomplished during the different phases of the double stroke, admission, expansion, exhaust and compression. From this we deduced the heat equivalent of the work in each one of these phases and of the total work. Generally, the two values of this latter, which

were obtained, one by the planimeter, the other by measurement of ordinates and calculation, differed less than one-half of one per cent., which is very small, especially for these small areas. Whenever the difference exceeds this proportion without an obvious cause, the diagram is rejected.

We must add as an essential element of our success, the extraordinary facility acquired by our engineer, M. Gonda, who is able to maintain for hours together, a régime nearly perfect, realizing whatever conditions are put upon him. The boiler pressure, observed every two minutes by a mercury manometer, hardly varies from 50 to 60 millimeters during an entire test; the temperature of superheating from two to three degrees; the brake hardly oscillates; the velocity, observed from the revolution counter every minute varies but one or two turns in 45, notwithstanding the governor is not at work. The number of turns made by the engine per 20 kilograms of steam employed, rarely varied even one per cent.

V.

In the month of March, last, we made, with the assistance of our students, eight tests of steam consumption of which four had one-tenth and four two-tenths compression, considering that the economy due to compression would be sufficiently marked by this difference. The engine was running non-condensing at about five and one-half atmospheres pressure. With the actual proportion of clearance, a cut-off at one-tenth stroke gave us nearly the conditions of complete expansion, and it would require, as it seemed to us, in the vicinity of three-tenths of compression in order that the compression might be complete. At three-tenths compression and one-tenth admission, however, the area of the diagrams became so small that the students, as yet little accustomed to this work, found them inconvenient to measure. For this reason we confined our tests to two-tenths. Following our custom, our tests made by the students have been rehearsed to assure ourselves that all would be in order, and the engine was run under the conditions of the test from 9 o'clock

in the morning, although the official test did not commence until 2.30, thus giving ourselves time for a preliminary examination.

The fact that we established by these tests was exactly the opposite from that which was expected. *The compression to two-tenths was more expensive than to one-tenth.* Before looking for the reason for this, it was deemed prudent to establish the fact beyond mistake; and for this purpose, we repeated with our corps of experimenters and our best students, the tests at three-tenths of compression and also without compression. This test confirmed fully the first results and permitted us even to establish the law, represented by the diagram, of the augmentation of consumption due to the augmentation of compression. Doubt being no longer possible, it was necessary to get at an explanation of the fact. This is presented with perfect clearness by our diagram of heat exchange, which we will here consider.

VI.

In the ordinary operation of engines, the live steam coming from the boiler is partially condensed against the enclosing cylinder walls during admission. This phenomenon is due to two causes: because the live steam comes in contact with the cold metal, and because it must compress and reheat the steam remaining in the cylinder at the moment that the steam valve is open for admission. This has received the name of "initial condensation."* It is this initial condensation, accompanied by a very energetic call for steam from the boiler, which causes all the trouble, which deranges all the predictions of a so-called theory which does not take it into account, which opens an abyss between such theories—however scientific they may be—and the practical theory of Hirn, which has taken account of this factor to the greatest possible extent. All the means employed to better the performance of the engine and diminish steam consumption have the same and single effect, to diminish the initial condensation.

* We prefer the term, loss of heat during admission.

After admission, the water coming from the initial condensation is completely and entirely re-evaporated by the heat imparted to the enclosing metal during each complete cycle. Of this re-evaporation one part is favorable, that which takes place during expansion; the other, that which takes place during exhaust, is lost and is consequently expensive. This loss can be considerably reduced by the use of the steam jacket and a proper degree of expansion. Superheating may have the same result.

Compression produced by the piston, having for effect the elevation of the pressure of the steam enclosed in the clearance space, has equally the effect of raising at the same time the temperature of the steam and that of the cylinder, and, consequently, of diminishing the initial condensation during admission. This fact is demonstrated by experiments which have on this point confirmed our expectations. It is during the compression, however, that the disturbing action of the walls makes itself felt. In order to reheat the enclosing walls the compressed steam is partially condensed. In this way there is produced *a preliminary condensation* (it is thus that we shall allude to it henceforth) which unites with the initial condensation to produce the prejudicial effect. *It is the sum of the preliminary condensation and the initial condensation which determines the extent of the prejudicial action of the metallic surfaces.* In our experiments this sum, of which one part, the initial condensation, was diminished, increased as a whole rapidly with the degree of compression because the preliminary condensation increased yet more rapidly. As is our habit in these tests, we have traced our diagrams of heat exchange, showing the areas representing the initial condensation (R_a) and the preliminary condensation (R_c). These have thrown a light upon the powerful disturbing action of the cylinder walls, which Hirn said is capable of reversing conclusions, apparently the most rational, based upon a theory which does not take them into account.

VII.

Having thus a clear conception of the physical rôle of compression, we have endeavored to determine the influence of the

clearance space and the velocity. To this end we placed on the faces of the piston a number of plates which reduced the space between the piston and the head from 11 to 3 millimeters. The volume, originally 7.9 per cent. of the volume generated by the piston, was thus reduced to 6.6 per cent. The consumption of steam was hardly diminished. The compression continued to act without considerable diminution, following the same law.

In our first series of tests we did not compress the steam sufficiently to bring it to a pressure equal to that of admission. In the new series, with the reduced clearance space, we hoped to do this, but the condensation, especially near the end of compression, became so active that the diagram, instead of continuing to rise, was terminated by a falling away of the curve abruptly at the end, as shown in the indicator diagrams herewith. We had worked only without compression and with a compression of three-tenths. We now carried the compression to four-tenths, with the same failure to attain a pressure equal to the initial.

During this time the engine was operated without steam in the jackets, the heat necessary to maintain their temperature serving only to reduce the extent of the phenomena without modifying their laws, and with a trap upon the steam chest for the purpose of eliminating a possible factor of error, the steam entered the chest at a temperature of about 200 degrees, a superheat of practically 45 degrees. The speed was about 45 revolutions per minute. The governor was not at work, our attendant as has been mentioned above, maintaining by close attention a uniformity of conditions.

For each run, without compression, at three-tenths and at four-tenths of compression, we made three tests, as nearly as possible under identical conditions, and for a definite study of the heat exchanges we have chosen from the three tests on each run those which most nearly accorded with the equation of Hirn.

In the run without compression, the steam valve was given no lead. When running at three-tenths and at four-tenths, a lead of 5 per cent. was employed.

Notwithstanding all our efforts, we have been unable to obtain the same diagram from the two sides of the piston, although we

could work more closely in ours than in an ordinary engine. On account of the greater velocity of the piston due to the angularity of the connecting rod, the steam was wire-drawn more on the head than on the crank end. It will be noticed on the indicator diagrams herewith, Figs. 2 to 7, that the expansion commences considerably before the admission port is closed, the point of closure being indicated by *D*, and that this effect is more pronounced in the diagrams from the head than in those from the crank end. This effect is produced on all engines, and if it is not more frequently noticed it is because observers have not ordinarily the means of determining, with the precision afforded by our machine, the exact point of closure. The same phenomenon manifests itself before the commencement of the compression indicated by the letter *C* on the diagram. We have mentioned in the description of our engine* that the mean height of opening of the admission ports with regard to time was greater in the crank end than in the head end. To correct this defect, we have endeavored to give to the head end an amount of lead which would produce the same mean port area as in the crank end. The lead of the crank end being one-tenth, we find this to be for the head end .114, and having arranged the engine to produce this result we may believe that the consumption of steam per revolution is divided equally between the two strokes. In any case we are sure that in no machine can a closer result be obtained, not even one which approaches this in accuracy. At all times for our study of heat exchange we have carried our scruples to the limit, made two complete and separate studies, one for the head and one for the crank end. These results differ so slightly that we will give here only those from the head end, the conclusions being the same.

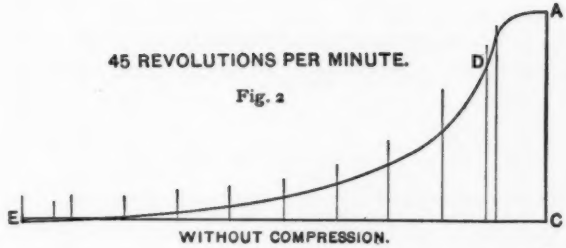
VIII.

Being desirous to obtain at the end of the compression a pressure superior to that of admission, we hope to find in greater velocity a means of arriving at that end. We repeated, therefore,

* See *Données relatives à la machine à vapuer du laboratoire de Liège*, Liège, Ch. Desoer.

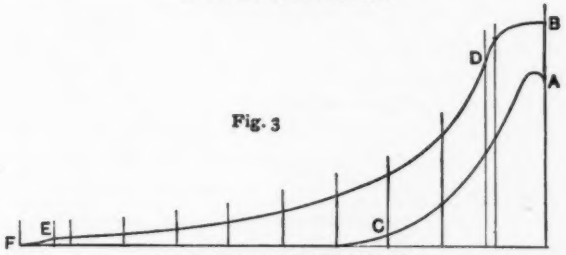
45 REVOLUTIONS PER MINUTE.

Fig. 2



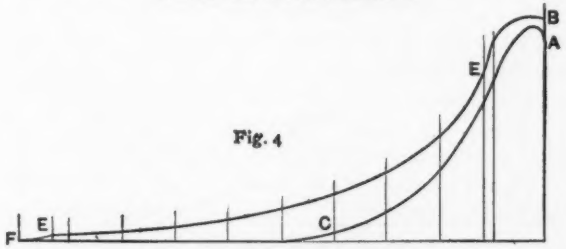
WITHOUT COMPRESSION.

Fig. 3



THREE TENTHS COMPRESSION.

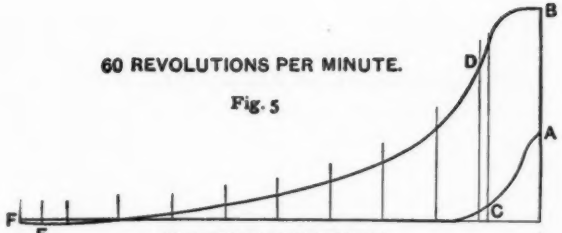
Fig. 4



FOUR TENTHS COMPRESSION.

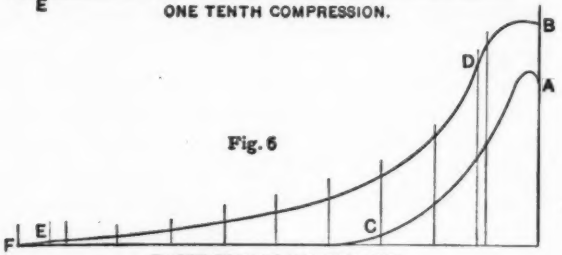
60 REVOLUTIONS PER MINUTE.

Fig. 5



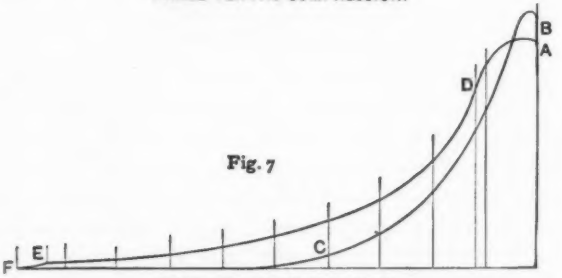
ONE TENTH COMPRESSION.

Fig. 6



THREE TENTHS COMPRESSION.

Fig. 7



FOUR TENTHS COMPRESSION.

the two tests, not only at 45 revolutions, but at 60 revolutions per minute, about, following always the same method. As shown in the last indicator diagram herewith (Fig. 7), we succeeded at four-tenths compression, but on the diagram from the head end only, which might have been predicted. At a velocity of 60 revolutions it was not prudent to work without compression, for which reason our series of tests was at one, three and four-tenths.

IX.

RESULTS AND CONCLUSIONS.

The principal results are shown in the accompanying table and by the diagrams, Figs. 8 and 9. In the table are given, first, the date and the conditions of the test, then the consumption in kilograms of steam per horse power hour. This is shown on diagrams 8 and 9 by the curves AB, to which have been added the figures from the table. Lines 4 and 5 give the weight of steam Mc and m_3 enclosed behind the piston respectively at the commencement and at the end of the compression, and line 6 the weight $Mc - m_3$ of steam condensed during the compression; line 7 gives the number of calories, R, that the steam has furnished to the cylinder walls during the compression. This number has been divided by the total number of calories Q (line 8) carried into the cylinder by the live steam at each stroke of the piston; and the quotient showing the ratio of these two quantities, given in line 9 of the table, has been transferred to the ordinates of the diagrams 8 and 9, being the curves CD.

Lines 11 to 16 refer to the admission, line 16 gives the ratio of the heat given up by the steam to the cylinder walls during admission to the total heat entering the cylinder, and the figures of the table are carried to the ordinates of Figs. 8 and 9 generating the curves EF. In line 18 of the table is found the ratio of the total heat furnished to the cylinder walls during both compression and admission, that is $R_c + R$, to the total heat Q as shown by the curves EG, Figs. 8 and 9. Lines 19 and 20 show the quantity of heat R_f actually lost by the action of the cylinder walls during the entire cycle, comprising re-evaporation during expansion and its ratio to the total heat Q. This has not been

carried to the diagrams Figs. 8 and 9, in order not to impair their legibility with an encumbrance of detail. This final conclusion would add nothing to that which is shown by the curve of consumption $A\,B$, except that the loss is due to the influence of the walls, which is sufficiently proved by the curve $E\,G$.

Date, September, 1897.	7	10	16	23	22	18
1. Compression commences at..	0	3 tenths	4 tenths	1 tenth	3 tenths	4 tenths
2. Revolutions per minute.....	45.41	45.37	44.82	61.68	60.86	61.73
3. Consumption of steam per horse power hour (curves $A\,B$, Figs. 8 and 9) kg.....	16.196	19.512	25.435	14.910	18.529	24.470
4. Weight of fluid remaining in clearance space at commencement of compression and acting during compression (kg.) Mc.....	0.001631	0.011099	0.014168	0.005161	0.011540	0.014349
5. Weight of pure steam remaining in the clearance space at the end of compression m_2.....	0.001631	0.006400	0.007193	0.004210	0.006814	0.007987
6. Preliminary condensation (kg. of steam) $Mc - m_2$.....	0.000000	0.004699	0.006975	0.000951	0.004726	0.006362
7. Heat communicated to the walls by this condensation (calories) Kc.....	0.0000	2.8367	4.2102	0.6187	2.8940	3.9596
8. Total heat carried into the cylinder at each stroke of the piston (calories) Q.....	18.3297	14.7060	13.5018	14.9232	13.0749	10.8891
9. Ratio of heat communicated to walls during compression to total heat Q carried into cylinder (curves $C\,D$, Figs. 8 and 9) $Kc : Q$.	0.0000	0.1929	0.3118	0.0412	0.2213	0.3636
10. Weight of fluid admitted (kg.) Ma.....	0.027223	0.021786	0.019984	0.021990	0.019328	0.016089
11. Weight of fluid acting during expansion $(Mc + Ma)$.....	0.028854	0.032885	0.034152	0.027318	0.030868	0.030438
12. Weight of pure steam at cut-off mo.....	0.019445	0.020554	0.020568	0.019329	0.020561	0.021091
13. Total weight of steam condensed during compression and admission, or sum of preliminary and initial condensations $Mc + Ma - mo$.....	0.009409	0.012331	0.013584	0.007989	0.010307	0.009347
14. Weight of steam condensed during admission or initial condensation $(Mc + Ma - mo) - (Mc - m_2)$	0.009409	0.007632	0.006609	0.007038	0.005581	0.002985
15. Heat given up to the walls by that condensation (calories) Ka	5.5361	4.3455	3.7943	4.2102	3.2713	1.8949
16. Ratio of the heat given up to the walls during admission to the total heat Q entering the cylinder (curves $E\,F$, Figs. 8 and 9) $Ka : Q$..	0.3020	0.2955	0.2810	0.2800	0.2502	0.1740
17. Total heat given up to the walls by the preliminary and initial condensations together $Ke + Ka$	5.5361	7.1822	8.0045	4.8289	6.1653	5.8545
18. Ratio of this total quantity of heat exchanged to the total heat Q (curves $E\,G$, Figs. 8 and 9).....	0.3020	0.4884	0.5928	0.3212	0.4715	0.5377
19. Heat lost by the action of the walls $Kf = Kc + Ka + Kd$..	1.1831	2.4429	3.2632	0.7923	1.9755	1.8168
20. Ratio of the heat lost to the total heat expended during the stroke $Kf : Q$.....	0.0645	0.1661	0.2417	0.0527	0.4511	0.1668

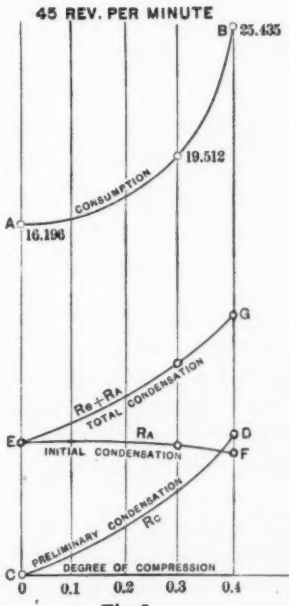

45 REV. PER MINUTE
B
25.435
19.512
CONSUMPTION
A
16.196
G
Re + RA
TOTAL CONDENSATION
E
RA
D
INITIAL CONDENSATION
F
PRELIMINARY CONDENSATION
RC
C
DEGREE OF COMPRESSION
0
0.1
0.2
0.3
0.4

Fig. 8

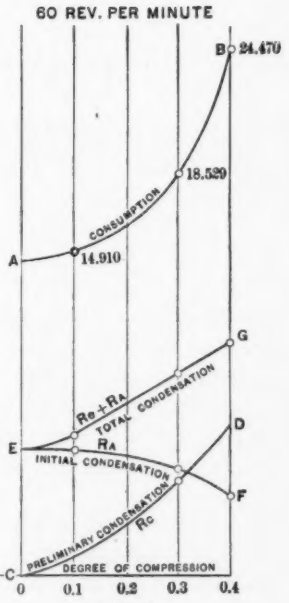

60 REV. PER MINUTE
B
24.470
18.529
CONSUMPTION
A
14.910
G
Re + RA
TOTAL CONDENSATION
E
RA
D
INITIAL CONDENSATION
F
PRELIMINARY CONDENSATION
RC
C
DEGREE OF COMPRESSION
0
0.1
0.2
0.3
0.4

Fig. 9

It results from the preceding:

First, that the velocity has no influence to change the law of the economy of compression, but reduces simply the magnitude of the phenomena.

That the consumption per horse power hour at 45 revolutions increases from 16.196 kg. without compression to 25.435 kg. at four-tenths compression, and that the loss is therefore

$$\frac{25{,}435 - 16{,}196}{16{,}196} = 57 \text{ per cent.}$$

That at 60 revolutions the consumption passes from 14.910 kg. with one-tenth compression to 24.470 kg. at four-tenths; that the loss is therefore

$$\frac{24{,}470 - 14{,}910}{14{,}910} = 64 \text{ per cent.}$$

The reason of this fact is that, although the initial condensation diminishes as the compression is increased, as shown by the curve EF, this diminution is very slow, while the augmentation of the preliminary condensation is very rapid, as shown by the curve CD, so much so that the total condensation $R_c + R_a$ augments rapidly as the compression is increased, as shown by the curve EG.

As to the definite loss of heat R_f due to the detrimental action of the cylinder walls, corrected by restitution due to re-evaporation during expansion, this increases from 6 to 17 and to 24 per cent. at 45 revolutions, the compression being respectively zero, three-tenths and four-tenths. At 60 revolutions this loss increases from 5 to 15 and to 17 per cent., the compression being respectively one, three and four-tenths. It has been found that at 45 revolutions three and four-tenths compression have been sufficient to condense respectively 43 and 40 per cent. of the steam enclosed in the clearance, which did not contain any water at the commencement, and at 60 revolutions there were 18, 41 and 44 per cent. of condensation following upon compressions of one, three and four-tenths.

X.

The fact of the loss due to compression in the cases covered by our experiments is therefore established and completely explained by the disturbing action of the walls of the cylinder. *Could not this have been predicted at least up to a certain point?* It seems to us that it could for the following line of reasoning, which to us appears very clear, since the establishment of the fact can be followed.

The steam which remains behind the piston at the end of exhaust is at a pressure of one atmosphere, about; the live steam coming from the boiler to mingle with this at a pressure of five atmospheres. It is necessary that the first steam shall be compressed to a pressure of five atmospheres. This work is unavoidable, and must be done either by the live steam alone if there is no compression by the piston, or by the piston alone if the compression is complete, or concurrently by the two methods if the compression by the piston is incomplete. The question resolves itself into which of these three methods is the most economical.

When it is remembered how small a proportion of the heat which is furnished to an engine is represented in the actual work of the piston, and this on account of the disturbing influence of the cylinder walls, one would naturally suppose that the return in heat of work effected by a piston to augment the thermal energy of the vapor will be equally small on account of the same disturbing effect of the metallic walls enclosing the vapor.

The heat produced by the work of compression does not remain entirely with the steam, a considerable part is taken up by the cylinder walls, and if at admission the live steam finds the walls warm, it must mingle with the vapor impoverished by a partial condensation, and just so much heat as it gives up to this vapor it loses for itself. Thus the heat brought to the cylinder by the live steam is not entirely applied to the production of work, but to remedy an enfeeblement which the walls had produced in the compressed steam as well as to the necessities of the walls which will be afterward uncovered during admission.

One might therefore—one even must—expect a feeble return

on the part of compression. Will it not be thus in all cases? For the reasons which we have given we have not extended our investigations to condensing engines, but now that it is not a question of verifying in practice the theorem of M. Zeuner, but a question of determining the economical properties of compression without seeking to render it complete any more than expansion, we propose to extend the tests to condensation and to different degrees of expansion.

Our last experiments have demonstrated that compression commences by superheating the steam and that the steam does not condense except in the last .05 of the stroke, when the velocity of the piston is reduced to about 45 per cent. of its mean value; but from the time that the piston arrives at .95 of the stroke for three or four-tenths of compression, or at .975 for one-tenth, the condensation is more and more energetic, to such an extent that the final amount falls to .51 for four-tenths of compression and at 45 revolutions per minute, and to .58 for three-tenths to .56, .59 and .82 respectively for four, three or one-tenth of compression and at 60 revolutions.

These facts suggest to us new tests under varying conditions, of which we will make known the results by another communication to the readers of the "Revue de Mécanique."

INVESTIGATION OF DISTORTION AND RESISTANCE OF FLAT HEADS.*

By Prof. C. Bach.

[Reprinted from "American Machinist."]

In his book on "Elasticity and Resistance of Materials," † the author discusses the theories and principles on which the distortions and resistance of flat surfaces to uniformly applied stresses depend, and then verifies his statements by practical demonstrations and tests covering square, oblong, circular and elliptical plates, fixed and supported at their edges, as is the case in flat cylinder heads, valve chests, handhole and manhole cover plates and the like.

In a recent paper in the "Zeitschrift des Vereines Deutscher Ingenieure," Nos. 41, 42 and 43, 1897, the same author publishes his latest investigations in this field, covering flanged heads of wrought and cast materials, and again demonstrates that his theory and formulæ are corroborated by actual tests made on a large scale. He deduces practical formulæ for ready use in designing flat flanged surfaces of any shape or material, and by which their distortions and resistances are easily determined.

The wrought flanged heads tested were five in number, varying only in thickness and radius of curvature of the corner of flange or fillet.

A hydraulic pump was so attached that any desired pressure could be applied and held, and a rigid eight-armed spider was so secured above and around each head that nicely fitting steel points passing through fifty-two holes in it would show the changes of diametral as well as axial shape. The position of all of these points could be measured by micrometers mounted over

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* Translated and abridged by Gus C. Henning.

† See "American Machinist," December 27, 1894.

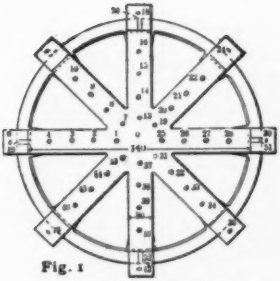

Fig. 1

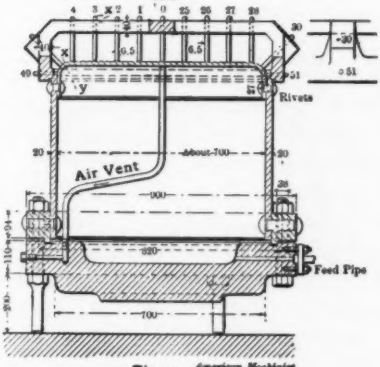

Fig. 2 *American Machinist*

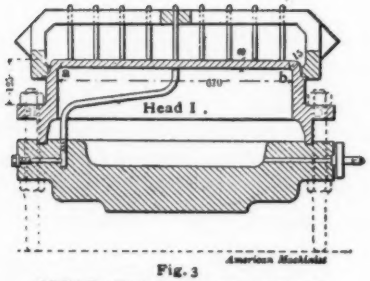

Fig. 3
APPARATUS FOR CAST HEADS.

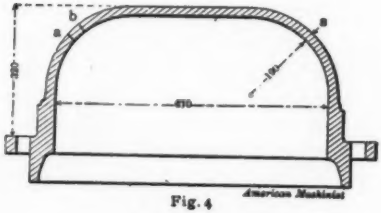

Fig. 4
CAST HEAD.

them, so that the actual changes of shape could be determined with the greatest accuracy.

Figs. 1 and 2 show the general arrangement of heads and spider for wrought heads, while Fig. 3 shows the same for cast heads. The dimensions are in millimeters.

While none of the wrought heads could be loaded to a point that would produce rupture, because excessive leakage due to distortion prevented it, the cast-iron heads were all fractured, as shown by Figs. 5, 6, 7 and 8.

After each application of pressure and release of same, the changes of shape were measured and plotted, thus giving not only the temporary and final change of shape, but also the permanent set. These are carefully plotted and studied, and demonstrate that there is a reversal of strains near the angle of flange (fillet), as there a reversed curve is produced in the heads. The location of this point of contra-flexure gives proof that the flexure of such heads can be calculated with the same precision as is the case in ordinary beams, and that, while at this point is located a neutral circular fiber, those on the under side within it are in compression, while those on the outer or upper side are in tension; while the reverse is true of all fibers beyond this neutral ring. The diagrams also show that bending and tension stresses coexist, and that with increasing distortion the central part of the plate acts on the flange to draw it toward the axis of cylinder.

The diagrams of distortion up to 5 atmospheres are concave toward the base line and convex to it beyond this point, or positively and distinctly beyond 6 atmospheres, and the distortion grows more rapidly than the pressures applied. This goes on to 9 atmospheres, thence to 13 atmospheres, during which period a straight line is drawn or distortion is proportional to loads. Then up to 20 atmospheres the curve again becomes concave, beyond which the line again becomes convex.

Diagrams of permanent set begin to show rapid increase after 5 atmospheres of pressure have been passed, growing apace under higher loads, when finally they become equal to distortion.

In the case of wrought heads it was noticed that the metal began to scale at x—y, Fig. 1, when pressures of 11–13 atmos-

pheres were reached, which shows that permanent distortion occurred, and that the maximum stresses existed at that point.

After reaching 7 atmospheres it was noted that time was an important element of distortion, and it required 25 minutes before any further change of shape ceased to take place at that pressure, while at 8 atmospheres it required 50 minutes. Removing all load after this pressure had been applied also showed the necessity of again waiting 15 minutes before the plate had come to rest, so that permanent set could be measured. The second head was similar to the first in dimensions and results.

The third differed from the previous ones in having a radius of fillet of 2.6 inches instead of 1.6 inches, with a thickness of .416 inch, as against .388 inch in the former.

The results were quite similar to the previous ones, except that the neutral circle of fibers had moved down quite into the flange.

The fourth head was still thicker, .80 inch, while the central part was somewhat "domed" initially.

The results obtained are again similar, merely occurring under increased loads and times. The fifth wrought flanged head had a thickness of .428 inch and a radius of curvature in fillet of .476 inch, and as this head was hand flanged it was not as regular as those previously tested.

All results were again similar to those previously obtained.

TESTS OF CAST-IRON FLANGED HEADS.

These heads, shown in Figs. 3 to 9, were made of good gray iron, as used for machinery purposes.

The first head, .808 inch thick, 26.8 inches diameter, broke at a pressure of 13 atmospheres in a line just within the fillet, beginning at under side. The fillet was almost a square corner.

In this case the resolution of forces would be about as follows: Assuming the inner surface to be uniformly loaded by a pressure p, and considering the flange as an abutment fixing the head, a strip of unit width is supposed to be cut across the entire head.

As in the case of a beam fixed at its ends, the maximum fiber strain will be found at the abutment and on the loaded surface,

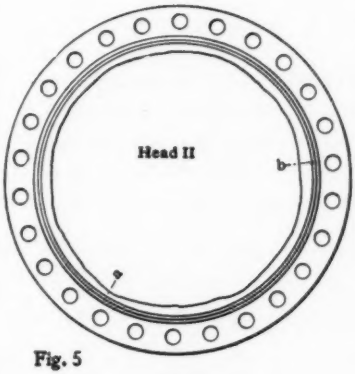

Fig. 5

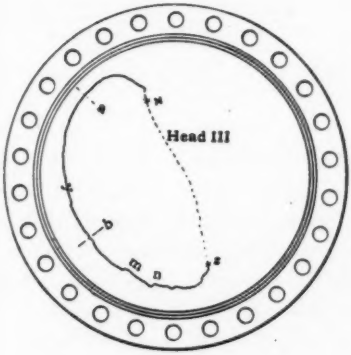

Fig. 6

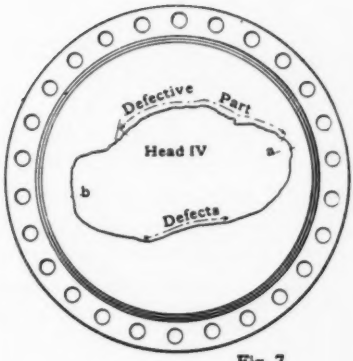

Fig. 7

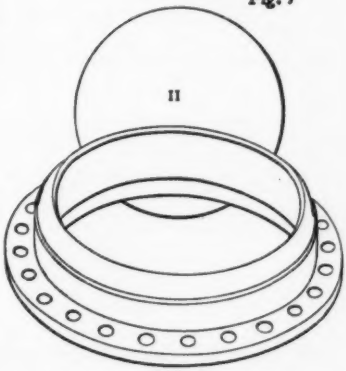

Fig. 8

Fig. 9

CAST IRON HEADS SHOWING LINES OF FRACTURE.

and is proportional to the bending moment $\frac{p\,l^2}{12}$,* which gives, according to the theory of flexure, the maximum stress as

$$\frac{p\,l^2}{12} = \sigma_b \frac{1}{6} s^2$$

$$\sigma_b = \frac{1}{2} p \left(\frac{l}{s}\right)^2$$

When,

p = internal pressure on head, in pounds per square inch.

l = length of element (= diameter of head), in inches.

s = thickness of metal, in inches.

σ_b = maximum bending stress.

At the center of head this will be reversed and equal to $\frac{p\,l^2}{24}$.

The reversal of strain will be found at a distance = 0.2113 l from the abutment.

RIVETED HEADS OF LOW STEELS.

A further study of the resistance of flanged heads with fillets of larger radius evolves the formula.†

$$K_b \geqq \left\{ \frac{1}{2}\frac{r}{s} + \varphi \left(\frac{a - 0.5\,r\left(1 + \frac{r}{a}\right)}{s} \right)^2 \right\} p \qquad (1)$$

in which K_b = assumed working stress for bending, a = diameter of head and φ = percentage of ultimate elongation of the material, the form of which shows that what is necessary to obtain greater resistance of thin heads is to increase the value of r = radius of fillet; s being the thickness of metal.

This essential factor r has been heretofore totally neglected in all formulæ for thickness of flat heads. In case of riveted heads the resistance of net metal between rivet holes controls the thickness to be used in cases where r is very great.

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* See "Elasticity and Resistance of Materials" by C. Bach.

† We omit this mathematical discussion because it would occupy too much space and is most ably given in the original work.

CAST-IRON HEADS.

Fracture occurred in the four heads at pressures of 13, 9.25, 20.5 and 41.5 atmospheres.

The author's formula for cast-iron heads is

$$K_b \geqq 0.8\left\{\frac{r}{s}+\left(\frac{a-0.5\,r\left(1+\frac{r}{a}\right)}{s}\right)^2\right\}p \qquad (2)$$

which gives, when assuming $K_b = 3{,}778$ pounds per square inch, bursting pressures of 11.9, 9.3, 18.4 and 42.6 atmospheres, or errors of +8.5 per cent., —0.5 per cent., +10.2 per cent. and —2.7 per cent., which may be considered unimportant when it is remembered that cast heads are always subject to initial cooling strains and are variable in thickness.

The author then discusses D. K. Clark's formulæ for the resistance of flat heads, and points out their errors due to incorrect assumptions, and dwells upon the fact that his formulæ and tests prove that the resistance of flat plates varies not as the thickness, but as the square of the thickness.

REMARKABLE ECONOMY TEST OF A LARGE COTTON-MILL ENGINE.

[Reprinted from "Power."]

We give herewith the detailed report of a test of an 1,100 horse power vertical cross-compound engine in the Atlantic Cotton Mills, at Lawrence, Mass. The test was conducted by Dean & Main, the well known mill and mechanical engineers of Boston, Mass. It is particularly interesting, aside from its primary object of total steam consumption, in its bearing upon the subjects of jacket and receiver steam, the superheating of high-pressure exhaust and the value of exhaust heaters between the engine and condenser. The engine is fitted with fixed main eccentrics, the cut-off eccentrics for both cylinders being controlled by the governor. The range of cut-off is from 0 to $\frac{8}{10}$ths of the stroke. The valves are set to allow a large volume of steam to be withdrawn from the receiver for use in other parts of the mill. During the test this steam was not withdrawn, hence more work was done by the low-pressure side of the engine. Test No. 2 was under the specified conditions, and its result, 12.87 pounds of dry steam, is on the contract basis. The vacuum in the cylinder was 27 and 26 inches for tests No. 1 and No. 2.

"MR. W. F. SHERMAN,

"Agent Atlantic Cotton Mills,

"Lawrence, Mass.

"Dear Sir: On February 17 and 18, 1897, we conducted a feed-water trial of your vertical cross-compound engine, for the purpose of ascertaining whether it fulfilled the guarantee for steam consumption made by the builders. The engine was built by McIntosh, Seymour & Co., of Auburn, N. Y., and was guaranteed by them to use not more than 14½ pounds of dry steam per horse power per hour. It is understood that the test was to be of one day's duration, but as the mill stops 55 minutes

at noon, there were really two tests of one-half day each. While these are short tests, from which there is no alternative, there were no errors of practical consequence because the boilers, being vertical and of the Manning type, have but small net water surface, and present no uncertainty in computing the allowance for differences of water levels at the start and stop.

"The engine is a vertical cross-compound having its shaft a part of the water-wheel shaft. It is provided with gridiron inlet and exhaust valves on both cylinders, and auxiliary cut-off valves of the same kind on both cylinders. The valves have positive motions throughout and the points of cut-off are determined on both cylinders by shaft governor. The high-pressure cylinder is jacketed throughout by steam of boiler pressure, and there are reheating coils in the receiver through which live steam of boiler pressure circulates. The low-pressure cylinder is unjacketed. During both tests the condensations from the jacket and reheater were weighed together on platform scales, the amounts of which are stated below. The temperature of the condensation was determined some 30 feet from the reheater. The boilers supplied steam to nothing but the engine.

"The precautions taken for accuracy in feed-water measurements were blanking all blow-off and other pipes connected with the feed-water system, and preventing all leaks.

"The contract provided for an initial pressure of 120 pounds of steam above the atmosphere in the high-pressure cylinder, and this was maintained as near as practicable. The steam was superheated at the engine, and the amount of this was determined by a correct high-grade Green's thermometer inserted in a deep well in the steam pipe within six inches of the cylinder. A nice test pressure-gauge was connected at the same point. A Green's thermometer was inserted in the inlet pipe to the low-pressure cylinder and close to the cylinder, showing the superheat stated below. The condenser was made by Bulkley.

"A feed-water heater was placed in the low-pressure exhaust pipe near the low-pressure cylinder, and the temperatures of the water as it entered and left were taken for the purpose of the information thereby gained, although it had no relation to the

contract for the engine. For the same reason the jacket and reheater condensations were determined. The feed water was weighed on accurate scales by an experienced man. The indicator springs were tested under steam on the government apparatus at the Brooklyn Navy Yard. The engine was taken in its every-day working condition, and the results, which are among the best recorded, are, so far as we can see, being duplicated in regular operation. After the trial the diameters of the cylinders while hot were measured, and the lengths of the strokes determined.

"In the table it will be noticed that the temperature of the injection and feed waters is stated as 32 degrees F. While this is unusually low, it was determined by five different high-grade thermometers, all which gave the same result. As the water in the river and canal, from which these waters came, was covered with ice, its temperature must be almost exactly 32 degrees.

"The following are the leading dimensions of the engine, and the results:

DIMENSIONS OF THE ENGINE.

Diameter of the high-pressure cylinder, inches	24.031
Diameter of the low-pressure cylinder, inches	48.031
Diameter of the high-pressure piston rod, inches	5.00
Diameter of the low-pressure piston rod, inches	5.00
Ratio of pistons' areas	4 to 1
Stroke of each piston, inches	48.00
Revolutions per minute, about	100
Piston speed per minute, feet, about	800

RESULTS OF TRIALS.	*First trial.*	*Second trial.*
1. Duration, hours	5.079	5.583
2. Number of revolutions per minute	100.794	99.633
AVERAGE TEMPERATURES.		
3. External air, degrees	37	42
4. Engine-room, degrees	65	65
5. Steam near high-pressure cylinder, degrees	359	371
6. Steam near low-pressure cylinder, degrees	312	309
7. Jacket and reheater drain, degrees	342	341
8. Injection water, degrees	32	32
9. Condenser discnarge, degrees	56	66
10. Feed water before entering heater, degrees	32	32
11. Feed water after leaving heater, degrees	94	101

AVERAGE PRESSURES.

12. Atmosphere by barometer, pounds	14.67	14.62
13. Steam at engine, by gauge, pounds	123.00	123.00
14. Steam at engine absolute, pounds	137.67	137.62
15. Initial in low-pressure cylinder above atmosphere, from indicator diagrams, pounds	10.00	14.50
16. Initial in low-pressure cylinder absolute, from indicator diagrams, pounds	24.67	29.12
17. Vacuum by test gauge, inches	28.00	27.10
18. Mean effective pressure in H.P. cylinder, pounds	33.69	43.92
19. Mean effective pressure in L.P. cylinder, pounds	11.19	13.91
20. Mean effective pressure reduced to L.P. cylinder, pounds,	19.61	24.89

SUPERHEAT.

21. Superheat near high-pressure cylinder, degrees	7.5	20
22. Superheat near low-pressure cylinder, degrees	74	61

POWERS.

23. Power developed by H.P. cylinder	365.2	470.6
24. Power developed by L.P. cylinder	492.9	605.8
25. Total horse power	858.1	1,076.4
26. Per cent. of power developed by H.P. cylinder	42.5	43.7
27. Per cent. of power developed by L.P. cylinder	57.5	56.3

STEAM USED BY THE ENGINE.

28. Total weight used by engine, jacket and reheater, pounds,	56,721	76,662
29. Total weight used by engine, jacket and reheater per hour, pounds	11,167	13,731
30. Total weight used by jacket and reheater	5,881	7,475
31. Total weight used by jacket and reheater per hour, pounds,	1,158	1,339
32. Per cent. of jacket and reheater steam to total used	10.4	9.8
33. Actual weight of total steam used per I.H.P. per hour, pounds	13.01	12.76
34. Do. corrected for superheat, pounds	13.05	12.87
35. Do. corrected for superheat, average, pounds	12.96	

"The result, 12.96 pounds, is 10.6 per cent. less than the guaranteed amount. The results on the two days furnish some interesting data in relation to the falling off in economy of a compound engine when it is underloaded. Taking the results of the second test as a standard, the load on the first day is 20 per cent. less while the steam consumption is but slightly over 1 per cent. more.

SAVING BY THE FEED-WATER HEATERS.

"The average increase in feed-water temperature caused by the heater for the two days is 65½ degrees, which, under the present conditions of temperature and steam pressure, is equivalent to a saving in coal of 5.6 per cent.

"The following table gives the rate of heat transfer from the steam to the water:

	First trial.	*Second trial.*
Temperature of water before entering heater, degrees	32	32
Temperature of water after leaving heater, degrees	94	101
Increase in temperature of water, degrees	62	69
Average temperature of water in heater, degrees	63	66.5
Absolute pressure in L.P. exhaust pipe, pounds	0.87	1.36
Corresponding temperatures exhaust pipe, degrees	99	111
Average difference of temperature between steam and water, degrees	36	44.5
Feed water used per hour, pounds	11,167	13,731
Heating surface of water in contact with steam, square feet,	234	234
Amount of heat transferred per hour, B. T. U	692,354	947,439
Heat transferred per degree of average difference in temperature per square foot of heating surface per hour, B. T. U.,	82	91

"Respectfully submitted,

(Signed), "DEAN & MAIN."

VICKERS' GUNS.

[Reprinted from "Engineering."]

Messrs. Vickers, Sons and Maxim, Limited, manufacture every type of ordnance, their plant, as we have shown in our preceding volume (LXIV, pages 760 and 791), being capable of dealing with guns of over 100 tons weight, but the demands of the artillerist are now confined within the limits marked by the 50-ton gun, hurling an 850-pound projectile from the muzzle with a velocity of 2,750 feet per second, and the automatic gun, firing as many as 800 shots per minute. All the intermediate types of guns need not be dealt with; the more prominent examples will suffice, but the dimensions and ballistics of all are shown in the accompanying Table. The large breechloaders for use in battleships include 12-inch, 10-inch and 9.2-inch caliber guns, while the quick firers are 8-inch, 6-inch, 4.7-inch, 4-inch and 3-inch weapons, with many Maxim and machine guns. The method of constructing most of the larger guns is known generally as the steel and wire-wound system.

An interesting feature of all the guns is the breech plug, originally invented by a Swedish engineer (Mr. Axel Welin). It is made in segmental portions, in steps of varying radii, as will be readily seen from Figs. 4 and 5. By this arrangement a plug divided, say, into eight segments, would have six segments or three-quarters of its circumference threaded for meeting the strains on the breech; while the ordinary parallel breech plug, with thread and plane surface alternating, has only half its circumference threaded, the other half being useless for resisting the back pressure in firing. This enables the plug to be shortened by one-third of its length, and proportionately lessens the weight. The reduction is of great importance, as the gun is shortened at its heaviest part, which means considerable reduction in its weight. The breech plug, too, can be more easily

BREECH MECHANISM OF VICKERS' 12-IN. GUN.

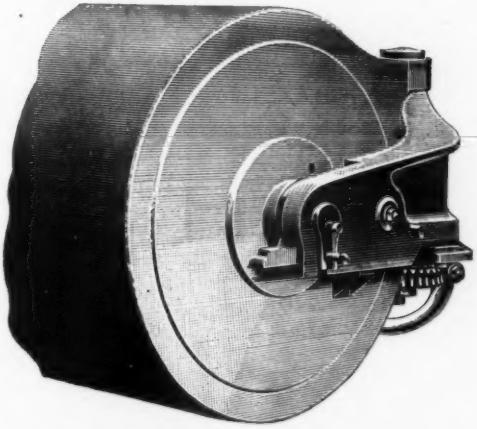


FIG. 4.

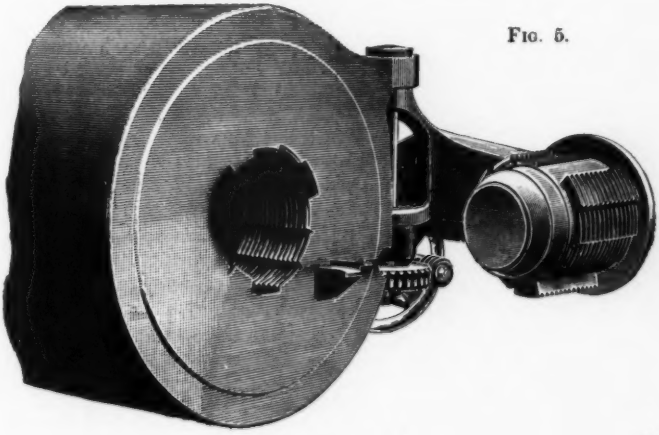


FIG. 5.

Type of gun.	Gun.													
	Diameter of bore.	Length of bore.	Total length of gun.	Diameter of chamber.	Length of chamber.	Maximum pressure in chamber.	Weight of charge.			Weight of projectile.	Total weight of gun, including breech mechanism.			
	in.	*in.*	*in.*			*tons.*	*lb.*	*oz.*	*gr.*	*lb.*	*tons.*	*cwt.*	*qrs.*	*lb.*
37 mm. 30 cal.	1.457	43.5	73.75	1.44	2.64	13	0	1	110	1.0	0	4	0	22
37 mm. 42.5 cal.	1.457	62.0	94.0	1.6	3.78	14	0	3	0	1.25	0	5	1	26
47 mm. 40 cal.	1.85	73.72	77.95	2.04	12.93	13	0	9	0	3.3	0	4	0	0
47 mm. 47.2 cal.	1.85	87.34	91.5	2.04	12.93	13	0	11	0	3.3	0	4	2	6
57 mm. 42.3 cal.	2.244	95.0	104.4	2.45	10.2	15	0	15	0	6.0	0	6	2	0
57 mm. 50 cal.	2.244	112.2	116.4	2.8	14.2	15	1	4	0	6.0	0	8	0	0
Naval **76.2 mm.** 45 cal.	3.0	135.0	138.0	3.5	19.0	16	2	9	0	12.5	0	14	2	14
Naval **76.2 mm.** 50 cal.	3.0	150.0	153.0	3.5	19.0	16	2	9	0	12.5	0	15	3	0
Field **76.2 mm.** 23.5 cal.	3.0	70.5	75.55	3.4	9.6	14	1	0	0	12.5	0	5	2	23
Mountain **75 mm.** 10.7 cal.	2.953	31.6	35.85	3.0	4.575	8	0	6	110	12.5	0	2	0	13
101.6 mm. 45 cal.	4.0	180.0	186.1	5.0	21.2	17	6	0	0	25.0	1	13	0	0
101.6 mm. 50 cal.	4.0	200.0	206.0	5.0	21.2	17	6	0	0	25.0	1	16	0	0
12 cm. 40 cal.	4.724	188.98	193.28	5.1	25.5	16	8	8	0	45.0	2	10	0	0
12 cm. 45 cal.	4.724	212.58	217.0	5.5	25.75	17	9	0	0	45.0	2	14	0	0
15.24 cm. 40 cal.	6.0	240.0	249.2	6.8	32.5	16	19	0	0	100.0	6	15	0	0
15.24 cm. 45 cal.	6.0	270.0	279.2	8.5	33.0	17	25	0	0	100.0	7	8	0	0
20.3 cm.† 45 cal.	8.0	360.0	371.7	10.0	43.0	17	52	0	0	210.0	18	16	2	0
23.36 cm.† 45 cal.	9.2	414.0	426.8	13.5	67.0	17	94	8	0	380.0	26	16	0	0
25.4 cm.† 42 cal.	10.0	405.15	420.0	11.5	63.35	17	100	0	0	450.0	28	4	0	0
31.48 cm.† 40 cal.	12.0	480.0	496.5	17.5	87.2	17	207	0	0	850.0	50	7	0	0

* Carriage and limber with accessories, and 40 rounds of ammunition.

Cordite is used in all guns.

Older types of 9.2-inch, 10-inch, 12-inch and 13.5-inch guns, as
mo

Muzzle velocity in feet per second.	Muzzle energy in foot-tons.	Penetration of wrought-iron plate at muzzle by Gavre's formula.	Penetration of steel plate at muzzle by Gavre's formula.	Rounds per minute.	Mounting. Weight of mountings complete with shield.*				Thickness of shield in inches.	Weight of shield.				Angle of elevation.	Angle of depression.
		in.			*tons.*	*cwt.*	*qrs.*	*lb.*		*tons.*	*cwt*	*qrs.*	*lb.*	*deg.*	*deg.*
1,800	22.5	1.9	1.5	300	0	3	0	22	¼	0	0	3	11	16	25
2,350	48.	3.3	2.6	300	0	3	2	5	No shield.			...		13	25
2,125	103.	4.5	3.5	30	0	9	3	0	½	0	1	3	0	18	15
2,400	132.	5.3	4.1	30	0	10	0	18	½	0	1	3	0	18	12
2,300	220.	6.2	4.8	28	0	12	2	0	$\frac{3}{16}$	0	1	0	0	20	20
2,500	260.	7.	5.4	28	0	12	0	0	¼	0	1	3	9	20	15
2,600	586.	9.2	7.1	20	2	11	0	0	2	1	12	0	0	20	10
2,700	632.	9.7	7.5	20	2	13	0	0	2	1	12	0	0	20	10
1,700	250.4	...	...	20		...			...	*1	4	0	0	17	5
918	73.	...	...	14	0	5	3	5	No shield.			...		26	10
2,700	1,263.	11.6	9.0	15	4	4	3	0	4	2	6	0	0	20	7
2,800	1,359.	12.3	9.5	15	4	10	0	0	4	2	6	0	0	20	7
2,494	1,940.	13.3	10.3	12	5	17	0	0	4	3	18	0	0	20	7
2,600	2,109.	14.1	10.9	12	6	5	0	0	4	3	18	0	0	20	7
2,530	4,437.	18.5	14.4	8	8	15	0	0	4	4	0	0	0	16	7
2,775	5,340.	21.1	16.4	8	9	5	0	0	4	4	0	0	0	16	7
2,750	11,012.	26.0	20.2	5	16	8	0	0	4	7	0	0	0	15	5
2,750	19,927.	34.3	26.6	...	Depending on type of mounting used.										
2,580	20,811.	32.3	25.0	...											
2,750	44,573.	45.9	35.5	...											

† Under manufacture.

as manufactured by Vickers, Sons and Maxim, Limited, are not enumerated in the table, but only modern guns making use of smokeless powders.

swung clear of the breech after unlocking, without any curvature, and without the usual longitudinal withdrawal. This can even be done with the De Bange obturator.

The breech mechanism for the 12-inch, 10-inch and 9.2-inch guns, illustrated in Figs. 4 and 5, is fitted with the necessary gear to enable it to be worked by hydraulic or other power; it is applicable to any gun of smaller or larger caliber, and is suitable for either a right or left-hand gun. The mechanism is so arranged that by turning the handwheel the breech plug is first rotated and unlocked, then drawn longitudinally to the rear until the obturating pad is clear of its seat, and finally swung out of the breech of the gun. The horizontal sliding bar mounted in the carrier has one end connected by a roller stud to the arm which is fixed to the hinge bolt of the carrier. On the top of the sliding bar are formed teeth into which is geared a pinion, pivoted in the recess in the carrier. This pinion is keyed to the shaft on which is fixed the actuating lever. Projecting from the actuating lever is the roller stud which works in a slot in the rear face of the breech plug to rotate it. On the stem of the carrier, on which the breech plug is carried, there is fitted, with freedom to turn, the sleeve with a forked arm projecting from it. On the outer circumference of the sleeve are three inclined grooves of increasing pitch. Three roller studs, mounted on a ring fitted into the bore of the breech plug, work in the inclined grooves of the sleeve in such a manner that a longitudinal movement is given to the breech plug, when the sleeve is turned by a roller stud, which projects inwardly from the face of the horizontal sliding bar, and works in the forked arm of the sleeve. A worm and wormwheel operated by a handwheel are carried in a suitable position at the breech of the gun, and when rotated, cause the movement of the actuating arm.

To open the breech the handwheel is rotated, and thus, by means of the wormwheel, the actuating arm is moved, causing the sliding bar to move horizontally. This revolves the pinion and the actuating lever, which in turn rotates the breech plug, at first slowly, and then more rapidly, until it becomes unlocked. The sleeve, which is held in position until the plug becomes un-

locked, by means of a projecting pin working in a groove in the face of the sliding bar, is now free to turn, and by continuing to move the sliding bar the projecting roller stud engages the forked arm of the sleeve and so turns it. The rotation of the sleeve causes the plug to move longitudinally rearwards by means of the projecting studs working in the inclined grooves of the sleeve. After the plug is drawn longitudinally rearwards the continued movement of the actuating arm swings the mechanism out of the breech of the gun.

The gun is arranged for firing by electric or percussion tubes, and its action is similar to that of our 6-inch quick-firing gun. Provision is made so that the mechanism can be worked by hydraulic gear. Suitable clutches are provided, so that the change from hand to hydraulic gear, or *vice versa*, can be easily and rapidly effected by the rotation of a small handwheel.

With a charge of 207 pounds of cordite, and using an 850-pound shot, a muzzle velocity of 2,750 feet per second, and a muzzle energy of 44,573 foot-tons, can be obtained with this very serviceable 12-inch, 50-ton gun, for which Messrs. Vickers, Sons and Maxim, Limited, have an admirable type of mounting for use within barbettes, whereby the gun can be rapidly worked in action, giving considerable rapidity of fire, without introducing any delicate or complicated mechanism.

The 8-inch and 6-inch, quick-firing, obturating guns of 45 calibers are equally remarkable in respect of the simplicity of their mechanism and the high energy developed. The guns are of steel-and-wire construction; and the total length from the breech face to the muzzle is 31 feet in the case of the 8-inch, 23 feet 3 inches in the 6-inch weapon. The 8-inch gun, with a charge of 52 pounds of cordite, and using a 210-pound projectile, attains a muzzle velocity of 2,750 feet per second, and a muzzle energy of 11,012 foot-tons. With 25 pounds of cordite for a charge, and using a 100-pound shot, a muzzle velocity of 2,775 feet per second, and a muzzle energy of 5,340 foot-tons, has been obtained with the 6-inch gun.

The breech plug is opened or closed by the horizontal movement of a hand lever. The same action rotates, locks or unlocks

the plug, swings it in or out of the gun around the pivot on which it is mounted, and causes the percussion and electric striker to make or break contact at the required positions during the working of the mechanism. The arrangement consists of a link, one end of which is so pivoted on a pin projecting from the rear face of the breech plug, that the link works in a plane parallel to the breech face of the gun; while the other end is pivoted to a short crank mounted on the plug carrier, and around the boss of this crank are formed "skew gear" teeth. The hand lever for actuating the breech mechanism is pivoted on the plug carrier, and moves in a plane at right angles to the breech face of the gun. Around the boss of the hand lever is fitted a skew-gear wheel, which gears with the skew teeth formed on the boss of the crank.

The whole is arranged and proportioned in such a manner that when the breech is closed, the hand lever lies close up to the breech face of the gun. The arrangement of centers and pivots, together with the relative lengths of the link and crank, provides great power when opening or closing the breech.

On swinging the hand lever away from the gun, so as to open the breech, the crank moves the link past the locking center a short distance, without causing any perceptible movement of the plug. The further movement of the hand lever causes the crank to turn, and by means of the link rotates the plug, at first very slowly (thus obtaining great power), and then more rapidly, until it becomes unscrewed. The carrier then moves with the lever, swinging the plug clear of the gun.

A loading tray is provided, which is automatically moved across the breech face and raised into the loading position when the breech is being opened, and lowered when it is closing. The firing gear is arranged for firing by electric or percussion tubes, and is operated by the movement of the hand lever and link. It is so arranged that the first movement of the hand lever, when unlocking the breech, acts on the firing gear and makes the gun absolutely safe before the breech plug commences to unscrew. By the continued movement of the link the empty tube or primer is automatically ejected. The form of breech

mechanism described, which is a patent of the company, embodies several marked improvements over existing designs. There is a considerable reduction in number of parts. The mechanism is quickly and easily taken to pieces, while the accessibility of the parts is a great feature. The lever, which opens and closes the breech by a horizontal movement, occupies a very small horizontal area, so that the mechanism is easily worked in a restricted space. An improved and strengthened form of loading tray has been introduced, whereby existing difficulties as regards the tilting of the shot are entirely overcome.

The casemate mounting for these two quick-firing guns only differs in slight details. It consists of a steel-top carriage resting on balls, running on ball bearings on a steel pivot. The cradle in which the gun slides is a cylinder; attached to the cradle are three cylinders, one to overcome the recoil and the other two (one on each side of the recoil cylinder) contain the springs for running the gun up to the firing position after the recoil. The connection between these three cylinders of the gun is made by arms projecting from the breech ring. The whole weight of the moving parts, gun, cradle, and carriage, is taken on the balls above referred to, so that the training is very easy. The elevating and training operations are performed by the rotation of two handwheels conveniently placed with regard to the shoulder piece against which the gunner leans. These two handwheels are worked on the left side of the mounting, which has also an auxiliary handwheel on the right side, so that, if necessary, two men can conveniently train the gun. The recoil cylinder is of the usual construction, being fitted with a valve key supported at both ends, the valve key being of stronger section than is usual, and the whole arrangement of fewer parts. The shield is of the usual casemate type, the pedestal being very strong, to withstand the impact of small projectiles. This type of mounting affords increased protection from shell fire by the construction of the top carriage, the front of which is of considerable thickness, while the general arrangement of the several parts, such as recoil cylinder, spring cases, elevating and training

gear, is well disposed and under exceptional protection. The parts are few in number, easily kept in good repair, very little attention being necessary. The form of cradle is of strong design and completely covers in the breech end of the gun, thus preventing dirt, grit, etc., impairing the working.

The 4.7-inch quick-firing gun is also of 45 calibers, the total length from the breech face to the muzzle being 18 feet 1 inch, and with nine pounds of cordite for a charge, and using a 45-pound shot, a muzzle velocity of 2,600 feet per second, and a muzzle energy of 2,109 foot-tons can be obtained. The breech mechanism is similar to that described for the 6-inch quick-firing gun (obturating). Sometimes a metallic case is used in place of a "De Bange" obturator, the firing and safety gear being modified to suit, and no shot tray is required.

The mounting is somewhat similar to the 6-inch quick-firing gun just described, but with this slight difference, that while the cradle in which the gun slides has a similar cylinder to overcome the recoil, there is only one cylinder for running the gun forward after recoil.

Another noteworthy weapon amongst those whose dimensions, etc., are given in the table is the 12-pounder, 3-inch quick-firing naval gun, a favorite weapon amongst the auxiliary armament on all warships. The breech plug and mechanism is similar to that described for the 6-inch quick-firing gun. With 2 pounds 9 ounces of cordite for a charge, and using a 12.5 pound shot, a muzzle velocity of 2,700 feet per second, and a muzzle energy of 632 foot-tons can be obtained. The center pivot mounting for this 12-pounder is similar to that of the 4.7-inch gun.

The 12-pounder, 3-inch, quick-firing, field gun is 23.5 calibers, and the characteristic feature of the carriage is the method of taking up the recoil. All parts of the carriage are free to recoil except the hydraulic buffer, which is placed between the side cheeks of the trail. The front end of the buffer piston is attached to the front end of the carriage, and a strong spade is fixed to the rear end of the hydraulic cylinder. The cylinder is further connected to the trail by chains. Around the part of the piston rod

which projects outside the hydraulic cylinder is placed a powerful spring, which is compressed at the same time as the rod is forced into the cylinder. The trail is of special form and length, so as to slide freely back and obviate all "jump." On firing, the spade is forced into the ground, thereby arresting all movement of the cylinder rearwards, but the trail, being free to move to the rear, forces the hydraulic cylinder and springs to assist in taking up the recoil, while the spring serves to run the gun forward into position again.

The gun is connected by trunnions to the top carriage, which is pivoted to the front part of the trail, so that it can be trained through an arc of eight degrees (*i. e.*, four degrees on either side of the axis of the mounting). This permits small adjustments in laying without any movement of the trail. If required, the hydraulic buffer can be removed in about one minute; the mounting may then be used as an ordinary field carriage, and the recoil, which will then be about seven feet, is checked by means of ordinary shoe brakes applied to the tires of the wheels. A rate of fire of twelve aimed rounds per minute may be obtained with the use of this mounting. This system affords an efficient method of absorbing the energy of recoil and returning the gun to the firing position without disturbing the laying, and, without subjecting the mounting to any excessive strain, combines the advantages of a quick-firing gun with the lightest possible construction of mounting, which is due to the length of recoil and to the mass of the recoil parts.

THE STETTIN FLOATING GRAVING DOCK.

[Reprinted from the "Engineers' Gazette."]

The relatively great increase in the building of floating docks in recent years is worthy of special reference in connection with the completion of the second large dock of this type, built for foreign owners within twelve months by one firm on the Tyne-side, namely, Messrs. C. S. Swan and Hunter, of Wallsend. The first of these was for Havana, which left the river Tyne in September last, and was towed to its destination in fifty-eight days. This dock is 450 feet in length, 102 feet in extreme breadth, and is capable of lifting a vessel of 10,000 tons, and was, up to its completion, the largest floating dock constructed according to the designs of Messrs. Clark and Standfield, of London, a firm which has had more experience with this class of work than any other, extending over a period of more than forty years.

A brief reference to the history of floating docks will, we believe, not be without interest to our readers. The first dock of the kind appears to have been made in the time of Peter the Great, at Cronstadt, by a British master mariner, whose vessel was requiring to have the exterior of its hull cleaned and repaired. Owing to the practical absence of tide in the Baltic Sea, it was impossible to resort to the usual means adopted in ordinary tidal waters, and so a hulk, named the *Camel*, was obtained, out of which the whole of the decks and internal fittings were removed, as well as one end of the vessel, and in place of the latter a gate was fitted, by which the vessel was admitted, and when the gate was closed the water was pumped out. Floating docks of this type also came into use in the United Kingdom, and even now are not entirely unknown here, although the tideless shores of the United States have been termed "the nursery of the floating dock," as an evidence of which it may be pointed out that at

present there are twenty-three floating docks at New York and only five graving docks. Mr. G. Rennie was the first person to construct a floating dock of iron, and also to adopt the idea of floating a ship on a closed pontoon, from which the water was pumped, obtaining the great advantage that the water pumped out was proportional to the weight of the ship. He constructed his dock with two sides, and one end as high as the vessel's bulwarks, having only one end open, by which the vessel entered and left the dock. The largest dock he constructed was for Carthagena, and was built in the year 1859. It is capable of lifting a vessel of 6,500 tons displacement, and its weight of hull, with machinery and fittings, is 4,400 tons. It is still in good repair, so much so that when the question of having a dock at Havana was first considered it was suggested to enlarge this old dock.

Messrs. Clark and Standfield's connection with floating docks practically dates from the year 1857, when Mr. Edwin Clark designed a hydraulic lift graving dock for the Victoria Dock, London, of 3,000 tons lifting power, as well as six pontoons of various lifting capabilities, ranging from 700 to 1,600 tons. Subsequently, three larger pontoons were constructed in the year 1861, two respectively of 2,200 tons and 2,800 tons, and in the year 1876 one of 5,000 tons lifting power. In the year 1867, Mr. (now Sir Frederick) Bramwell designed a dock for St. Thomas in the West Indies, in which the sides consisted of continuous lattice girders, and which is still at work. In the year 1869, the Bermuda floating dock, designed by Mr. Campbell, was completed and towed out to its destination by two ironclads. It was designed so as to enable it to be careened by pumping water into the upper compartments of one side—but this operation appears to have been so dangerous as only to have been carried out once, namely, in Portsmouth Harbor. With gates on each end it was capable of lifting 10,000 tons besides its own weight, which was 8,600 tons. After a time the ironwork of the inaccessible portions of the dock seriously deteriorated, so that it was decided to fill the pontoon portion and part of the walls with concrete. In the year 1871 a hydraulic lift graving dock,

THE STETTIN FLOAT

MESSRS. CLARK AND STANDFIELD, ENGINEERS.

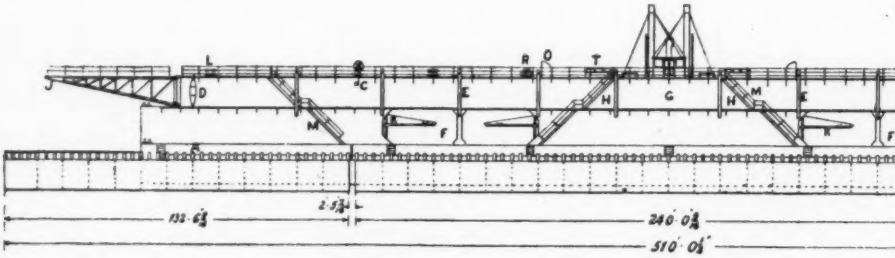


Fig. 1. LONGITUDINAL VIEW.

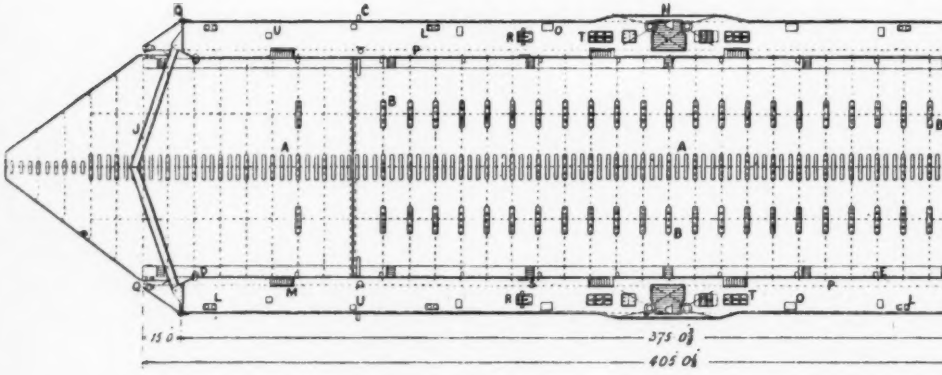
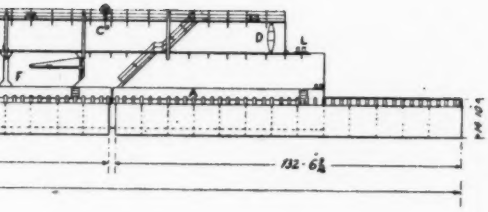


Fig. 2. PLAN.

ATING GRAVING DOCK.

MESSRS. C. S SWAN AND HUNTER, BUILDERS.



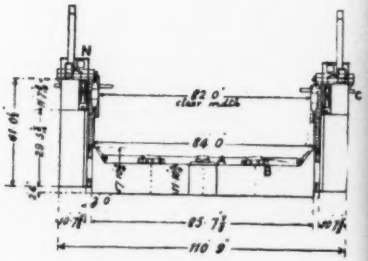
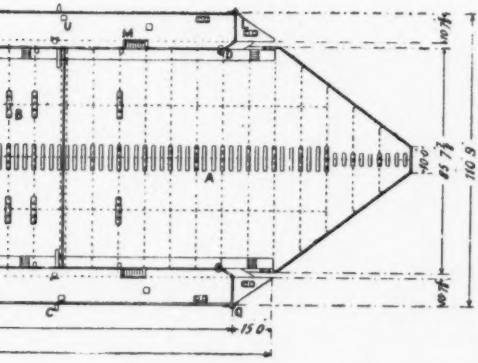


Fig 3. CROSS SECTION



KEEL BLOCKS	A	BOLLARDS...	L
SLIDING BILGE BLOCKS	B	ACCOM'ATION LAD'RS	M
SIDE SHORES	C	VALVE HOUSE	N
ROLLER FENDERS ...	D	COMPANIONS	O
SPRING TIMBERS ...	E	BELAYING CLEATS ...	P
GANGWAY OPENINGS	F	MOORING CLEATS ...	Q
BOILER ROOM	G	WINCHES	R
ENGINE ROOM	H	FAIRLEADS	S
FLYING GANGWAY ...	J	SKYLIGHTS	T
HAND CRANES	K	HATCHES	U

capable of being utilized by vessels of 4,000 tons displacement, was designed by Mr. Clark, for Malta, as well as a pontoon of 2,500 tons, and in the year 1874 another of this class of floating structures able to lift 1,200 tons. In the year 1872, the same gentleman designed a hydraulic lift dock of 8,000 tons power for Bombay, as well as a pontoon capable of lifting 6,500 tons.

A new departure was initiated by Messrs. Clark, Standfield and Co., in the year 1877, by the designing of a depositing dock for Nicolaieff, which had only one wall, so that vessels could enter it in three directions, and it could accommodate vessels of ordinary beam, as well as those of the *Popoffka* type, which were as much as 120 feet in diameter. This type of dock has also been adopted at Barrow-in-Furness, Vladivostock and Barcelona, in each case in accordance with Messrs. Clark and Standfield's designs. A modification of the depositing dock, known as the "offshore dock," has also been introduced by this firm, in which the pontoon is a continuous structure, and stability is obtained by attaching the dock to strong columns sunk in the foreshore instead of to a floating outrigger, although this latter arrangement is also sometimes retained. The first of the "offshore docks" was built at Hamburg, in the years 1887 and 1888, and two years later one was built at Cardiff, which, seven years later, was extended. There are also now two at North Shields, one at Flensburg, one at Copenhagen (built last year), one at Stockholm, which has an outrigger, as also have two of these docks now building for Genoa and Astrakhan. A small offshore dock is also at present being constructed for Grimsby by Messrs. Clark and Standfield.

Returning to the floating graving docks, it may be noticed that two years ago one of 2,300 tons lifting capability was built for the Mexican Government, while a double sided Rennie type of dock has recently been built at Amsterdam capable of lifting 7,500 tons, both to the designs of Messrs. Clark and Standfield.

As already indicated, the Stettin floating graving dock exceeds in size that built for Havana, being 510 feet in length over all, and 110 feet 9 inches extreme breadth. We illustrate it on the opposite page, Fig. 1 being a longitudinal view, Fig. 2 a plan and Fig. 3

a cross section. The height from the bottom of the pontoon to the top of the walls is 43 feet 6½ inches, and the internal width is sufficient to allow vessels up to 82 feet beam to be docked with a draught of water of 24 feet over the keel blocks. The bottom of the dock consists of three pontoons, the center one being 240 feet long, divided by three longitudinal bulkheads and by four 'thwartship divisions, thus forming sixteen water-tight compartments. The two end pontoons are 132 feet 6 inches in length, similarly divided into eight compartments. One of these end pontoons was launched separately from the remainder of the floating dock, as, owing to its great overall length and immense flotative power, there was a considerable danger of the launching at one time of the entire structure being abortive, and in any case of considerable damage being sustained. The two side walls are connected to the pontoons, and the latter to one another, by heavy bolts and nuts, so as to be readily disconnected to permit of the docking of the several portions on the floating dock itself, for which purpose large lugs of heavy steel forgings are provided at intervals along the walls of the dock, each of these lugs having eight holes to receive large bolts for suspending the portion of the dock requiring to be cleaned, painted or repaired. The walls, two in number, have each an overall length of 405 feet 0½ inch, a breadth of 10 feet 7⅝ inches and a moulded height of 41 feet 0½ inch. Like the pontoons, they consist of rectangular structures plated all over and stiffened on the inside by a series of angle frames that are strongly gussetted at the corners, diagonalized and cross strutted. These frames are spaced every 2 feet 6 inches, but every fourth one is in the form of a partial bulkhead, and at intervals there is a complete water-tight plate bulkhead. The sides are also stiffened by strong horizontal stringers, the one which comes level with the top of the altars being in the form of a partial deck. At a height of 29 feet 6 inches the walls are divided by a complete water-tight deck, and the chamber above this, into which water is never admitted, serves as engine and boiler rooms and general store rooms.

Between the level of the partial and engine deck two large gangway openings, 60 feet by 14 feet high, are left in the walls,

forming an easy method of access to the pontoon deck, and also giving light and air to the bilges of the ship. The partial and complete bulkheads of the walls, also the girders in the pontoons, are continued through the skin plating and stiffened by strong double angles. These are likewise pierced with large holes. The positions of these projecting angles, both vertically and in plan, is so arranged that they come directly opposite to the similar angles on the outside of the pontoons, the edges of the two series almost touching. The actual joint or connection between the walls and the pontoons is made by means of double fish plates that are bolted on to each side of the projecting angles. The holes on the fish plates and angles are slightly coned, so that the bolts draw all up into true contact and make each pin take its share of the work. At the height of the top of the gangway passages a light running deck is outrigged from the walls, forming a useful stage from which the ship can be shored or stages slung for painting the hull. The top deck is of a width of 13 feet 9 inches, being outrigged on the inside, thus affording a broad, level platform on which are placed the valve houses from which the whole of the manipulations of the dock are carried out. It is protected by a hand railing all around. Ladders with easy treads lead from the top deck to the broad altars and pontoon deck at suitable intervals.

Special attention has been given to the berthing of the vessels. For this purpose steam winches are fitted on the top deck for hauling them into position. Two pairs of side shores, consisting of heavy timbers, contained in recesses in the walls, are provided. These shores are screwed out by a worm and rack worked from the deck. Large rolling fenders are fixed at each internal corner of the dock, and ten spring fenders at equal distances along the inner side of the walls. In addition, there are ordinary running bilge blocks. These consist of a lower part of steel which can be placed anywhere on the deck of the dock, and therefore, if necessary, concentrated under any special part of the ship, and a timber or sliding part, in the form of a wedge, which can be hauled in under the bilges of the ship, by means of chains worked from the top deck, as much as six feet. The dock is fully pro-

vided with minor fittings, such as rubbing timbers, belaying cleats, ringbolts and mooring bitts. Swinging gangways are placed at one end of the dock, which not only serve as a means of communication from one wall to the other, but can also be used as crane jibs, and as their joint strength is sufficient to support a weight of twenty tons at their extremity, they will be found very useful for dealing with propellers and such heavy weights.

The whole of the dock is constructed of mild steel, fastened with iron rivets. The material has nowhere to support a greater strain than 11.0 kilos per square millimeter (7 tons per square inch), while the rivets work only at 7 kilos (4½ tons per square inch). In all the principal elements the stress has been kept below this figure, the main transverse girders that support the ship working only at 4.7 kilos.

The pumping installation comprises four sets of compound vertical engines, having cylinders 12 inches and 20 inches in diameter, and 10 inches stroke, working with steam of 130 pounds pressure, each indicating 125 horse power. The boilers, four in number, are of the ordinary multitubular marine type, each having two furnaces. Either of the two engines in each wall can obtain steam from either of the boilers in the same wall. The engines were supplied by the Wallsend Slipway and Engineering Co., Ltd., and the boilers by Messrs. Riley Brothers, Stockton-on-Tees. Each engine is connected to two 15-inch centrifugal pumps having 30-inch discs. These pumps are horizontal, and are driven by means of shafts carried at their upper ends on ball bearings, so minimizing the function. The pumps are by Messrs. Gwynne and Co., Holborn, and are sufficiently powerful to lift a vessel of 11,000 tons displacement in two and a half hours. The valves, which were constructed by Messrs. Blakeborough, of Brighouse, are controlled from two valve houses, one being placed about amidships in the top of each wall.

Throughout the entire structure flanged work has been largely introduced, all the partial bulkheads being of flanged steel plates, so reducing the riveting work as well as the additional weight incurred when angles and plates are adopted. A great feature of the progress that Messrs. Clark and Standfield have been able

to make in the designing of their docks, due to their extended practice and to the introduction of mild steel, has been the reduction in their weight. Their first depositing dock, built for Nicolaieff in the year 1877, had 51 tons of material in it for every 100 tons of lifting power, while in the Havana dock this was as low as 44 tons, and in the case of the dock now being described is only 41 tons.

Another noteworthy feature, both in the designing and construction of this Stettin floating dock, is the speed with which the work was performed. It was on October 11th, 1897, that Messrs. Clark and Standfield, after receiving a telegram asking them to meet the Vulcan Company at Stettin, arrived at that port. On that day and the next, details were discussed, and they were in a position to get out a firm estimate of the cost of the dock. They returned home on the 15th, and set to work on the specification, general drawings and detail drawings of the internal design of the dock, with all scantlings, engine power, pumps, diameter of pipes, and, in fact, a builders' specification complete enough to be signed at Stettin with the contractors for building the dry dock within eight days after they had started the work, so that the contract was signed at Stettin on the 23d October, and the first list of quantities for ordering were sent out on the 25th October, and on the first of the next month the first plates were delivered and work begun, so that within twenty days from the first intimation that such a dock was required it was actually being constructed. The time guaranteed by the builders for this dock delivered afloat ready for work at Stettin was ten months, this including the time to tow the dock across the North Sea and up the Baltic. A bonus was, however, offered by the company if the dock was delivered within nine months, and as a matter of fact the dock was delivered within eight months of signing the contract. The actual work of construction was greatly facilitated by using the multiple punching machine, which Messrs. Swan and Hunter had obtained, previously to building the Havana dock, from Messrs. De Bergue and Co., Ltd., Manchester. This machine requires no setting out of the holes, and any necessity for templates is altogether dispensed

with. It was fully described and illustrated in "Engineers' Gazette," Vol. X, pages 277, 278.

The extremely short time in which these docks can be built has already been touched upon, and it is interesting to note that the cost of constructing them is very low when the cost of an ordinary graving dock which will take vessels of the same size is taken into consideration. We find that the contract price for the Stettin dock is only £91,000, and this price includes the large item for towage from the Tyne to Stettin and the heavy insurance for the voyage. The Havana dock, which is somewhat heavier per ton of lifting power than the one forming the subject of this article, cost only £119,000, delivered afloat and ready for work in Havana, and this sum included the cost of insurance and towage for a voyage of 6,500 miles. Finally, we might mention that the sum of £110,000 would be sufficient to cover the cost of a floating graving dock of such dimensions that it would be able to lift any ship in the British Navy.

BASIC REFINED STEEL ON THE CONTINENT.*

By Mr. C. E. Stromeyer.

My opportunities for studying what I have ventured to call basic refined steel, and comparing it with acid steel, have been exceptionally favorable and extensive, both in English, German, Austrian and Belgian works; and I believe that this experience may help to familiarize the members of this Institution with a material which has proved itself equal, if not superior, to steel made in this country. Although it is produced in a basic furnace, I do not wish to class it with the two other basic qualities which are made, respectively, in a Thomas (basic) converter or in a basic open-hearth, because these two qualities have not earned for themselves in this country a good reputation in shipbuilding yards and boiler shops. In fact, the word "basic," when applied to steel, is to many ears but another name for "rotten." To tell shipbuilders in this country that German ships and boilers are almost exclusively built of "basic" steel awakens their curiosity, but to volunteer the further information, that failures with such plates are rare, is to court being regarded as a romancer. Although the details of the manufacture of acid steel are sufficiently well known in this district, it will be necessary to refer to them occasionally; and as there are three basic processes, and not merely two, as is generally supposed, they will have to be discussed somewhat in detail.

The object of Messrs. Thomas and Gilchrist in their invention was the removal of the phosphorus out of the pig iron during the time that it was being converted into steel, and the commercial success of their process was due to the fact that many iron ores and the resultant pig irons contain large percentages of phosphorus which, if allowed to remain in the steel, as it would

* Paper read at the Institution of Engineers and Shipbuilders in Scotland, Glasgow.

do in any acid furnace, would make the steel cold short. It was the removal of a comparatively large amount of phosphorus, say 2 to 3 per cent., which they aimed at, and for distinction's sake the methods recommended by them will be called Thomas-Bessemer and Thomas open-hearth processes, while the third one will in this paper be called the basic refining process. The last named is in many respects very similar to that of the Thomas open-hearth, because an open hearth with a basic lining has to be used, but with this difference, that the materials with which such a furnace is charged are nearly, if not quite, as free from phosphorus as those which are used in the acid open-hearth. In fact, as will be explained further on, acid steel is sometimes passed through the basic furnace in order still further to refine it.

When Mr. Henry Bessemer invented his now famous converter, it was believed that the rise of temperature in the molten metal was chiefly due to the combustion of the combined carbon, but recent investigations show that a charge of pure cast iron, *i. e.*, one composed only of Fe and C, would blow cold, whereas, if it contains a large percentage of silicon, the melting temperature of steel could easily be reached. Cast iron intended for this process is, therefore, made to contain much silicon, and is commercially known as Bessemer pig.

When the two elements, C and Si, are present in large quantities, they do not continuously burn away at the same rate, although just when the blowing operation is completing they both disappear together, so that, although the spectroscope can give no indications as to the presence or absence of silicon, the necessary information is obtained by watching the carbon lines. When they disappear, both the carbon and silicon have been burnt out; but not so the phosphorus, which does not commence to burn, or only to a very slight extent, until the carbon has disappeared, and as it also gives no indications, in the spectroscope, the attendant in charge of the converter has to proceed as follows:

He is, first of all, supplied with the results of the chemical analysis of the pig iron to be used, which tells him the relative proportion of carbon to phosphorus; as soon as the blowing engine is started he counts its revolutions and notes their num-

ber at the instant when the carbon lines disappear; a very simple proportion will then tell him how many more revolutions are required to consume all the phosphorus, and when they have been completed he stops the engine, for the process is practically finished, except that the ferro-manganese, etc., have to be added.

Unfortunately for the final product, the information obtained from the chemist is never quite reliable, more particularly if the pig is run direct from the blast furnace without the use of a mixer, and naturally, therefore, the duration of the second blow is never quite the right one. If stopped too early, all the phosphorus will not have been removed, and the resultant steel will be cold short; if continued too long, the oxygen in the blast will attack the iron, and a large percentage of the oxide formed will dissolve in the metal, giving to it some of the objectionable qualities of burnt iron. This uncertainty as regards obtaining a material of a definite composition is evidently one of the reasons why Thomas-Bessemer steel cannot be used for ships and boilers. It is well known that the combustion of the phosphorus in iron will only take place in the presence of the basic slag, and for this reason a large quantity of lime has to be added in each Thomas-Bessemer charge.

It appears that, at a white heat, silicon and carbon are chemically stronger than phosphorus. They, therefore, are the first to combine with the oxygen of the air, which is blown through the molten metal; the carbon oxide, being volatile, escapes, while the silica combines with any basic substance at hand. In the acid converter it combines with oxide of iron, and in the Thomas converter with the lime of the slag, or the magnesia of the lining. In order, therefore, that the latter, which is very expensive, shall not be wasted away in this manner, Thomas pig is made to contain little silicon; and as the combustion of carbon supplies practically no heat, the percentage of phosphorus should be a high one, for the combustion of this element, like silicon, also supplies much heat.

The calorific values are: Carbon, 4,340 calories, (Fah.); silicon, 14,000; phosphorus, 21,000; but from these very substantial deductions have to be made, not only because of the heat

escaping with the white-hot gases, which weigh $7\frac{1}{2}$ times as much as the carbon burnt, $4\frac{1}{2}$ times as much as the silicon, and 11 times as much as the phosphorus, but also because of the heat required for tearing either of these elements from the iron with which it is combined. Some heat is, of course, generated by the combination of the silica and phosphoric acid with the lime.

It is thus seen that the percentage of phosphorus must be at least equal to that part of the silicon which has been kept out of the pig, otherwise the charge will blow cold; and the general practice is to make it about $2\frac{1}{2}$ per cent. In districts where the phosphoric ores are not sufficiently rich, the necessary heat has to be supplied by melting and heating the pig in an open hearth instead of in a cupola, otherwise the metal in the converter loses its fluidity when it approaches to the qualities of mild steel. It then gets lumpy, which can be noticed by the jerkiness of the flame, and the process has to be stopped before all the phosphorus has been extracted. It thus, strangely enough, appears that the original amount of phosphorus must be high in order that none may remain in the finished Thomas-Bessemer state.

The contact of the highly phosphoric slag with the molten steel is another trouble. From what has already been said about the antagonism or rivalry between silicon and phosphorus, it will readily be understood that the two, finding themselves together in the slag, do not live in perfect harmony. Silicon appropriates to itself, firstly, rather more than its own weight of oxygen, forming silica, and in addition about nine times its own weight of lime, whereas the phosphorus is not allowed to take any oxygen while silicon is in the metal, and the phosphoric acid formed is only allowed to join itself to any excess lime, every pound of which will absorb up to $\frac{1}{4}$ pound of the acid; or, in other words, 10 pounds of lime are required for every 1 pound of phosphorus in the pig. Even then a small quantity of phosphorus remains in the molten steel, a rough estimate fixing it at $\frac{1}{20}$ per cent., when the superimposed slag contains 20 per cent. of silica and phosphoric acid. But this is only true for very mild steel of less than 25 tons tenacity, which is practically pure iron.

As has already been remarked, carbon has a greater affinity than phosphorus for oxygen. If, therefore, ferro-manganese, with its high per centage of carbon, is thrown into a charge of mild Thomas steel, it first comes in contact with the phosphoric slag, for it naturally floats on the surface of the steel, and an exchange takes place; the carbon and manganese combine with the oxygen of the phosphoric acid, while the phosphorus, in parting with its oxygen, leaves the lime and enters the steel. For this reason some works run off the greater part of the slag and throw in more lime before introducing the ferro-manganese. Others do not add this alloy until the steel is being run into the ladle, in which case there is, of course, the danger of getting it irregularly distributed.

TABLE I.—THOMAS-BESSEMER STEEL PLATE ONE-HALF INCH THICK.

Position of sample.	Edge of plate.		Center of plate.			
	Lengthways.		Lengthways.		Crossways.	
In ingot.	Stress. Tons per sq. in.	Elongation. Per cent. in 8 ins.	Stress. Tons per sq. in.	Elongation. Per cent. in 8 ins.	Stress. Tons per sq. in.	Elongation. Per cent. in 8 ins.
Top end.....	26.4	24	25.8	5*	29.5	20½
Bottom end.....	26.4	23	28.5	19	28.4	23

* This sample broke with a crystalline fracture.

These remarks apply to both the Thomas-Bessemer and open-hearth processes, and it will thus be seen that they are not particularly well suited for a material like ship and boiler steel, which must contain a relatively high percentage of carbon. Inquiries into the manufacture and behavior of the first-named material having awakened my curiosity, an ingot of a high-carbon Thomas-Bessemer charge was cast and rolled into a plate

8 feet long, 3 feet wide by ½ inch thick, which was cut up into about 60 test pieces intended for various experiments, including punching, drifting, flanging, riveting, etc.; but the preceding, and a few other preliminary tests, showed the material unreliable, so that the other experiments were abandoned.

Four of the six tensile test pieces were analyzed, and showed the carbon to be 0.145 per cent., manganese 0.60 per cent., silicon a trace, phosphorus varied from 0.057 to 0.095 per cent. Two temper bends were good. Twelve cold bends with sheared edges were all bad, many were quite brittle. Some samples were punched and bent; they cracked, not at the hole, but at the sheared edges. The most curious result was obtained with two tensile test pieces which were first planed on their edges and then each had a hole drilled into it. In one sample tested lengthways, it elongated from .81 inch in diameter to 1.05 inches, and tore through the hole with a crystalline fracture at a stress of 30 tons per square inch. The other sample, with the fiber crossways, elongated its hole from .81 inch to .98 inch, and broke with a crystalline fracture, not through the drilled hole, but ¼ inch away from it. The maximum stress was 30 tons on the section of the metal on either side of the hole, and at the fracture it was much less. It will be admitted that a material which fulfils, or nearly fulfils, the usual conditions as to tenacity, elongation and tempered bends, and then fractures in the testing machine at the side of a drilled hole, and which besides will not bend cold, is not suitable for ships and boilers, even if, as might be possible, only one out of a hundred charges were to behave in the same erratic manner. As nothing more could be learned by further experiments, these were not continued.

The Thomas open-hearth process, lasting almost as many hours as it takes minutes to blow a Bessemer charge, naturally affords better opportunities for improving the steel, and it must be admitted that good results have been obtained, but the presence of the highly phosphoric slag, which in volume is sometimes equal to the metal, must always be a source of great anxiety, so that a reliable material can only be produced by the most diligent attention, and this cannot always be expected. This subject

will be better understood by comparing the Thomas open-hearth with the acid open-hearth. Both are producers, which is not the case with a converter. The ore which is used for the purpose of oxidizing the carbon loses its oxygen, while the iron thus formed increases the weight of the charge, and if there were no other losses, this increase would amount to from 3 to 3½ per cent. for every 1 per cent. of carbon, silicon and phosphorus originally contained in the pig. Thus, if they sum up to 5 per cent., the ore would add 15 per cent. pure iron, making a total of 110 per cent. instead of only 95 per cent. as in a converter.

But this idea cannot be thoroughly carried out in the acid open-hearth, because the ore may not be introduced until the pig iron has been melted, and by that time the greater part of the carbon and silicon will have been oxidized by the flames, and are, therefore, not available for the reduction of the iron ore, which, if it had been introduced at first, would have dissolved the silica bottom of the open-hearth, and the life of the furnace would thus be materially shortened. Iron ore (oxide), being a basic substance, would, of course, eat into the furnace sides above the molten metal; it is, therefore, added to the slag, only in small quantities at a time, and is then quickly converted into iron by the carbon and silicon in the steel; but when these have been reduced to small percentages, the oxidizing action of the flame makes itself disagreeably felt, through the superimposed slag, by burning, and, of course, wasting the steel, even while it still contains carbon. Thus, when a very mild quality of steel with little carbon is aimed at, the acid open-hearth is clearly not a producer but a waster. The large amount of iron oxide which would under such conditions exist in the slag, must seriously injure the lining of the open-hearth and thus shorten its life, and it is thus quite clear that the acid open-hearth is not suited for turning out the very mildest qualities of steel; in fact, its natural product is a material of from 25 to 30 tons tenacity, and doubtless for this reason these were the limits originally fixed upon for ship and boiler steel.

In the Thomas open-hearth the conditions are, as it were, re-

versed; the furnace lining being basic, is not attacked by iron ores, and these may therefore be charged with the pig, and the chemical reaction between the two can proceed undisturbed, because they are well covered with a large quantity of lime, which has to be introduced early so as to absorb the silica as it is formed. The weight of the steel is therefore materially increased by the addition of ores, which may be even present in excess without loss to the charge, for the slag, being very thick, permits of no chemical action on the part of the flames. It is thus possible to extract practically every trace of carbon, and the resultant steel, or rather pure iron, is now largely used for dynamo magnets.

The natural product of such a furnace is a very mild steel of less than 25 tons tenacity. As soon as an attempt is made to increase the tensile strength by the necessary additions of ferro-manganese, the danger is at once incurred of reintroducing phosphorus from the slag into the steel. The Thomas open-hearth process does not depend for its heat on the combustion of silicon and phosphorus, as is the case in the converter; the pig to be used need therefore not necessarily contain much of the latter element, but the silicon should, of course, be low, so as not to injure the furnace lining, and also because it would prevent the phosphorus from leaving the metal. As both silicon and phosphorus require ten times their weight of lime, 1 per cent. of either element in the pig has to be neutralized by about 30 per cent. (volume) of lime.

It is almost needless to say that the basic open-hearth has troubles peculiarly its own. One, which is frequently mentioned, is that the lime dust settles on the ganister roof and in the air passages, and, under the influence of the prevailing white heat, eats away the silica bricks. Occasionally sufficient heat penetrates to the boundary between the dolomite lining and the ganister surroundings, the two substances, of course, combine, and forming a very fluid slag, eat their way further down. The channels thus formed are generally deep and sometimes quite narrow, like mouse holes, at other times they are very large and destroy the furnace.

I was fortunate enough to witness two such mishaps after dark,

and a grander sight cannot easily be imagined. The first warning was given by the appearance of a red-hot patch at a point about 4 feet away from the furnace mouth. Before the ladle could be placed in position and the furnace tapped, one furnace side had melted through, and the white-hot steel and slag burst out, forming several cascades, which melted many of the cast-iron columns of the surrounding stages as if they had been made of ice; the molten mass then spread itself out in front of the furnace. Nobody was hurt, but, in the anxiety to break up the escaped steel before it got cold and hard, the strong overhead traveling crane was called into requisition, and was made to pull in a slanting direction, until the shed gave unmistakable signs that the crane and the roof were going to fall on top of us. The second accident was not so serious, half the charge being tapped into the ladle.

After these preliminary remarks it will be easier to explain in how far the basic refining process differs from that of the Thomas open-hearth. The same furnaces are used, but instead of charging much phosphoric pig iron, a little scrap, much lime and the necessary amount of iron ore, the refining furnace takes at most 25 per cent. pure pig, 75 per cent. scrap, very little lime and no iron ore; for, as the layer of slag (lime) is thin, the flame readily oxidizes the carbon in the pig iron. The pig is, in fact, necessary to balance this reducing action, as well as to prevent the cold scrap from coming into contact with the white-hot basic bottom, which would thereby be seriously injured.

Soon after the charge is melted, it is found to have been refined to almost pure iron, the carbon and silicon of the pig, as well as the small percentage of phosphorus in the whole charge having disappeared. Several of the charges which passed through my hands contained less than 0.01 per cent. of phosphorus. The pig-iron intended for this furnace is neither a Bessemer pig, for it contains little silicon, nor a Thomas pig, for it contains little phosphorus. The scrap may be either iron or steel, the only condition with all these materials being that they shall not contain much sulphur, for this is not extracted by the basic refining process. Sulphur, when it exists alone in steel, is not nearly so

injurious as when it occurs combined with phosphorus, for these two elements seem to react on each other, and to intensify their respective bad influences, while manganese, as is well known, produces the opposite effect.

There being few impurities in the charge to begin with, it is not necessary to add much lime for their absorption, but even the little which is thrown into the furnace, and which is required as a protection for the iron from the flame, is in excess of the chemical requirements; the steel is, therefore, in contact with a slag containing very little phosphorus, and there is practically no danger of reintroducing this element when the ferro-manganese is added.

It will thus be seen that although the natural product of the basic refining furnace is a mild steel, or a pure iron, it is also capable of turning out a pure material with a high percentage of carbon. Among upwards of fifty charges made by this process, and tested by me in every conceivable way, none were unsatisfactory, either as regards obtaining a definite quality (it seemed possible to work within 1 ton), or as regards their behavior under the severest mechanical treatments. These latter included not only the ordinary tensile and temper bending tests, but also tensile and bending tests of sheared, punched, drilled, annealed tempered samples, drifting tests, and such manipulations as doubling up imitation treble-riveted single-butt joints, doubling up or flattening out Z-beams, formed by riveting together two angles, four folding plates, with or without a punched hole in its center, and also several severe forge tests, particularly as regards welding.

Steel producers in this country who find it difficult to obtain even sufficient scrap for the acid open-hearth, will doubtless wonder where their Continental competitors obtain the very much larger quantities required by the process under consideration. There is, of course, this difference: Scrap for the acid furnace must be pure; it may neither be red short nor cold short; it must contain neither much sulphur nor much phosphorus. Scrap for the basic refining furnace ought not to be red short, but it may be quite cold short; in fact, the worse it is in

this respect, the smaller will be its percentage of sulphur, for when both it and the phosphorus are high, it is practically impossible to make anything of such steel or iron, which therefore never finds its way into the market nor thence into the scrap heap. When the phosphorus is high the amount of lime has to be increased, but not at all to the same extent as in the Thomas open-hearth. In spite of this advantage, there can be no doubt that Continental steel makers have for years past been confined to using newly-manufactured scrap; about 15 per cent. are returned from the plate shears, and 60 per cent. have to be got elsewhere. In one district where the Thomas converter was in full swing, producing rails, beams and sleepers, large quantities of very serviceable scrap with about $\frac{1}{10}$th per cent. phosphorus could be got, but only as long as trade was brisk. When, as sometimes happens, the Thomas converters are lying idle, while the basic refining furnaces have plenty of orders, it has been found necessary to charge the latter with ingots from the Thomas works. I was unable to ascertain whether these contained the usual admixture of ferro-manganese, but in case the practice were carried out systematically, it would not only be costly, but would increase the percentage of phosphorus if such addition were made. Considerable trouble seems also to have been experienced in charging the open hearths with these heavy converter ingots, for they melted slowly, and, being cold, affected the lining. It would, of course, be an easy matter to cast smaller ingots, and instead of charging them cold they could be stored in soaking pits.

The charging of some of the Continental open hearths is done by mechanical means, and although this is a great relief to the men, particularly during their very hot summers, little or no time is saved, because the scrap can be introduced faster than it melts. Pig iron, of course, melts more easily.

In districts where scrap is permanently scarce, the idea of manufacturing it regularly is strongly entertained, and, strange as it may appear, the puddling furnace is looked upon as the most likely channel for supplying the cheapest and most suitable scrap. The production of a good wrought iron is, of course,

not necessary, and as attention need only be directed towards the removal of silicon, sulphur and cinder, any mechanical puddler would answer. In America the rotary furnace is said to have been successfully adopted, and, as their steel is manufactured on lines very similar to those followed on the Continent, this process is expected soon to be adopted in Europe. At Witkowitz, in Austrian Silesia, the scrap, if one may call it so, is produced in small acid converters, which remove all the silicon; the molten steel or scrap is then run direct into the basic refining hearth, each one requiring about three or four blows to fill it. Six and even seven charges have been got out of these open hearths in twenty-four hours. Such refining furnaces will have a long life, and, on account of their many charges, will show a heavy production. The general run of Continental furnaces take charges of from 10 to 20 tons, each heat lasting about six hours.

Frequent samples are, of course, taken during the refining process, and its progress is thus ascertained. When all the impurities have been removed, which is effected simply by the excess oxygen of the flames and without the addition of any ores, then the ferro-manganese, or, perhaps, spiegel is added, and when it has been thoroughly incorporated with the steel the charge is at once tapped, for a delay of one minute effects perceptible reduction both of the carbon and manganese. The mixing is accelerated in some works by poling, but as the charges tested by me were perfectly uniform in quality, although not all treated in this way, it was impossible to say whether the poled steel was better than the other. Instead of using ferro-manganese, the necessary carbon was in some works added in the form of charcoal, and no manganese found its way into the steel; the results were said to be highly satisfactory, but it seemed doubtful whether by this means a tenacity of thirty tons can be reached without imparting hardening properties to the steel, and I have been informed that this process is not reliable for ship and boiler steel.

Steel made by any of the three basic processes is said to contain dissolved oxide of iron, no matter whether the percentage of carbon, due to the final admixture, is low or high, and this

oxide is blamed as being the cause of many of the bad qualities of Thomas steel; the suggestion has, therefore, been made and acted upon of refining the metal in a basic furnace and charging it into an acid open hearth before adding the carbon. Such a proceeding must be costly, but it is said that the resultant steel is almost as good as that from crucibles. A modification of the idea is, perhaps, to be found in the following practice: The metal in a basic refining furnace is raised to an exceptionally high temperature, and is then poured into a ladle lined, as usual, with silica, the ferro-manganese being also thrown in; the casting of the ingots is not proceeded with until about a quarter of an hour has elapsed, but always before the metal begins to solidify; this allows plenty of time for the perfect amalgamation of the manganese and carbon, and for the expulsion of the oxide of iron.

As regards further operations on the refined steel, the only points worthy of note are that the ingots are mostly cast from below, about six to twelve at a time. Generally these are then rolled without being hammered. They are cast about 12 to 15 per cent. heavier than the plates (into which they are to be transformed) will ultimately weigh, and are of about the same proportions as the cogged slabs of our works, *i. e.*, about five to six times as wide as they are thick. These ingots had every appearance of being solid up to the very top, and that the quality was uniform will be seen by a glance at Table II, the distance of those samples marked crossways being only about 6 inches from the top or bottom end of the plate. Of course, the centers of those tested lengthways would be about 6 inches further away, but those cut from the center of the plate almost touched it.

It may be as well to mention here, that the ingot moulds were placed in two, or more generally in three groups, each group being fed by a central stand pipe. After rolling the ingots, six test pieces were cut from one plate of the first (bottom) third of the charge, as well as from one plate of the last (top) third of the charge; three of these test pieces come from the top end of each plate and three of these pieces from the bottom end of each plate. (See Table II.) In only one of the works were the ingots ham-

mered before rolling, but without reducing them much in size, the main object appearing to be to square them. It was stated that the chemical composition of steel intended to be rolled direct had to differ somewhat from that intended for the hammer. The unhammered ingots could be rolled into perfect plates, and, judging from sketches which were made at the time, it was only amongst the hammered steel that the edges of the plates were at all torn. Possibly hammering was necessary on account of slight red shortedness.

Ingots which are neither cogged nor hammered are naturally of tapered form, and if uniformly rolled out would be converted into plates which would be wider at one end than the other, and then there would be much waste; but by entering the slabs diagonally into the rolls, and pulling alternately at either of the small corners, they are drawn out until the plate is fairly rectangular.

The black line in Fig. 1 is the shape of the ingot after it has been rolled flat, it is then passed through the rolls in the direction of the arrow. The point *a* is thereby drawn out to a_1, and the sides *ac* and *ad* are stretched slightly concave. The reverse is the case with the other half of the slab, the lines *cb* and *cd* being altered into convex ones, and naturally the distance aa_1 is greater than bb_1 The slab is now turned through an angle of 90 degrees (see Fig. 2), and the corner *c* is drawn out more than the corner *d*, the result being an approximate rectangle with irregularly-shaped sides, as shown in black line, Fig. 2, which, as the plate grows longer and longer, appear to be almost straight. The rolling is then proceeded with in the ordinary way. By pulling at the corners *b* and *d* the final shape can be made to approximate to that of an end plate of a boiler.

Although the basic refining process is suitable both for mild and hard qualities of steel, I was aware that it was the mildest qualities only which were generally made in it, and that there might be some difficulty in obtaining satisfactory results with ship and boiler qualities. Most of the charges intended for testing were, therefore, arranged to have a tenacity of 31 tons, and some, of course, exceeded this point a little, yet in all cases the

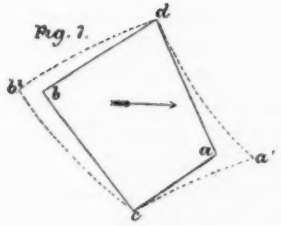


Fig. 1.

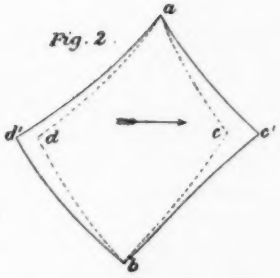


Fig. 2.

tests were highly satisfactory; in fact, it is doubtful whether any acid open-hearth could produce a steel plate $1\frac{3}{8}$ inches thick, having a tenacity of 31.8 tons per square inch, which would, as did a sample of basic refined steel, stand a temper bending test to a radius of $\frac{1}{2}$ inch, the edges of the sample being left ragged just as they came from the shears. In general it was found that ordinary untempered test pieces of this steel, and plates up to 18 inches wide and up to $\frac{1}{2}$ inch thick, could be bent and closed up double, even although the sheared edges had not been removed. Three-quarter inch plates with sheared edges, would stand bending to a radius of 1 inch to 2 inches; the edges of thicker plates had to be planed, but then they would bend and close up double under the steam hammer. The various tortures to which plates and angles from this material were subjected, have already been mentioned, and the tensile tests contained in the following Table II may be taken as a fair average example as regards the uniformity attainable.

TABLE II.—TENSILE TESTS FROM TWO ONE-HALF-INCH PLATES FROM ONE CHARGE OF BASIC REFINED STEEL.

Position of sample.		Near edge of plate.		Near center of plate.			
		Lengthways.		Lengthways.		Crossways.	
Charge.	Ingot.	Stress. Tons per sq. in.	Elongation. Per cent. in 8 ins.	Stress. Tons per sq. in.	Elongation. Per cent. in 8 ins.	Stress. Tons per sq. in.	Elongation. Per cent. in 8 ins.
Top.....	top end.....	31.4	21	31.6	20	30.6	22
	bottom end...	31.1	21½	31.4	21	31.4	21
Bottom....	top end.....	31.5	22	30.7	23	30.7	23
	bottom end...	31.7	23	31.7	23½	31.7	22

This material welded perfectly well.

Four annealed samples gave stresses varying from 30.4 to 31.3 tons per square inch, while in four tempered samples the ten-

acity varied from 43.9 tons to 44.7 tons per square inch. The temper bending tests were all good, two of the samples doubling up close. All the cold bend tests (unannealed) bent up close. In neither case were the sheared edges removed.

A comparison of one plate of Thomas-Bessemer steel (see Table I) with fifty basic refined charges which were rolled into both thin and thick plates, and which behaved as well as the samples in Table II, confirmed the opinion which is universally held on the Continent, that the two steels, although they both go by the name of "basic" cannot, as is done in this country, be classed together. It has been my endeavor to make this clear, and, if possible, to pave the way for the introduction of what I have ventured to call basic refined steel, a material which seems to surpass that produced in the acid open-hearth, and which may, perhaps, be the stepping stone to higher limits of tenacity, and further reductions of scantlings.

THE TROPENAS PROCESS OF STEEL CASTING.

[Reprinted from the "American Machinist."]

The following information, abstracted from a paper presented at the Cincinnati meeting of the American Foundrymen's Association by Alexander Tropenas, will doubtless be of interest to many of our readers. The facility with which, at comparatively small expense, the process may be employed in the ordinary iron foundry, must commend it to serious consideration. The process has been successfully put in operation in Great Britain and in most European countries, while at least one plant in the United States (for the Driggs-Seabury Gun and Ammunition Company, Derby, Conn.) is ready to start, so that it is no longer in the experimental stage.

The Tropenas process consists in the use of a special converter, in which the pig iron, melted beforehand, is treated and converted into steel. This vessel, like all other converters, is a sheet-steel shell, lined inside with refractory bricks of ganister. The shell is fitted with two hollow trunnions, carried on two pedestals, so that the apparatus may be tilted according to the requirements of the operation, *i. e.*, charging the melted pig iron, pouring the steel, etc.

Upon one of the faces of the converter, and in a plane parallel to the axle of the trunnions, are fixed two wind boxes, connected by a conduit to the hollow trunnion communicating with the blowing apparatus. Inside of the lower wind box a row of horizontal tuyeres terminate, from 1¼ to 2 inches in diameter. They open into the converter high enough to be always above the surface of the metallic bath.

In the upper wind box a second row of tuyeres is placed; they are flattened, and their free section is equal to about three-fourths of that of the lower tuyeres. This row of tuyeres is placed above the lower row. The upper wind box is connected

to the air main by an independent pipe, fitted with a valve, allowing to regulate at will the flow of air discharged by the top tuyeres, or to suppress it entirely. All the tuyeres are so placed that they cannot communicate any gyratory motion to the metallic bath.

When the melted pig iron has been run into the converter, the latter is turned up in such a manner as to bring the lower tuyeres near the metallic bath, but always above it. The top tuyere air valve is now closed. Then blowing is commenced in this position until the carbon flame appears. When the operation is well under way, the top tuyere valve is opened, so as to admit through these tuyeres a supplementary quantity of air, which penetrates into the converter at a certain height above the metallic bath. This air meets the gases escaping from the metallic bath, and burns them, thus producing a zone of high temperature, which, by radiation, considerably increases the heat of the charge.

The operation is stopped when the flame disappears—this corresponds to extra soft steel. Recarbonization is then made in the converter by means of a final addition, accurately weighed, thus allowing to produce exactly the hardness and quality of steel required.

The blast pressure required for good working varies between 3 and 4 pounds, according to the kind of pig iron treated.

The characteristic features of the Tropenas process are the following:

1. Low-pressure blast, always above the surface of the metal, and through the lower or "fining tuyeres."

2. Disposition of the tuyeres in the horizontal plane so that the jets of air arriving above the bath cannot impart to the latter any gyratory motion.

3. Great depth of the metallic bath, so as to avoid churning and stirring of the latter during the operation.

4. Arrangement above the "fining tuyeres," and independent of the latter, of a supplementary row of "combustion tuyeres," so as to burn the combustible gases escaping from the metallic bath, and thus increasing the final heat of the steel.

Blowing above the surface gives a much better quality of steel than the other pneumatic processes which blow from the bottom, or more or less below the surface of the metallic bath. During the whole time of the Tropenas operation the bath remains perfectly quiet, and this is entirely different from all other processes, in which a continuous mixture of metal scoria and air takes place. The steel produced by our process is pure, and contains hardly any gas in dissolution. The operation being particularly quiet, there is no projection of steel, or very little, through the neck of the converter.

By the use of the top tuyeres the carbonic oxide (CO) arising from the metallic bath is transformed into carbonic acid (CO_2), thus greatly increasing the temperature of the final steel, without increasing the cost price. The steel obtained being hotter, and consequently more fluid, allows the gases to escape more easily, and when the metal is poured into the molds it is perfectly quiet. Owing to its high temperature, and consequent great fluidity, the pouring is much easier, and the steel produced is better utilized, as no skull remains in the bottom of the ladles.

At the end of the Tropenas operation, before any final addition is made, the product obtained is practically pure iron. This enables to produce, currently, a very large number of steel castings for dynamos and other similar uses, possessing a very great magnetic permeability, and which, when analyzed, show from 99.75 to 99.80 per cent. of pure iron. These pieces are particularly sound, and when machined show no blow holes or similar defects.

It is easy to understand that the Tropenas metal, produced in such a state of great purity and at such a high temperature, enables us to make the most varied final additions with the view of producing different qualities of steel, from the softest to the hardest, and all the intermediate grades; this being obtained by merely modifying the final addition, according to the product required.

It is necessary to observe that, though the metallic bath is practically quiet during the operation, the reactions caused by the "fining" blast are quite sufficient to secure a perfect homogeneity of the charge. This is clearly demonstrated when we

pour a 2-ton heat into hand ladles for manufacturing small pieces. The steel from the first to the last ladle is absolutely the same. The working of the Tropenas converter is not difficult. It requires, of course, some knowledge, but any intelligent foreman can be taught in a few weeks the management of apparatus.

Practice has shown that the products obtained are very regular, and the signs of the operation are so clear that it is very easy to stop it at the proper time without the use of the spectroscope, when the metal is then completely decarbonized, and contains but very small quantities of the elements originally held in the pig iron. The bath at the end of the operation, being merely liquid iron, practically pure, it is a very easy matter to add a known quantity of final addition to obtain exactly the hardness and quality wanted.

The waste of metal during the operation has been the object of special researches. The average, taken from a great number of operations, show that the loss at the cupola varies between 5 and 6½ per cent. The waste at the converter, during the blow, varies between 10 and 12½ per cent. The average total loss in the cupola and converter is therefore about 17 per cent.

The pig iron usually employed by us for manufacturing steel castings has the following analysis:

Silicon, . .	from 2.50 to 3.50 per cent.
Manganese, . .	from 0.50 to 1.25 per cent.
Carbon, . .	from 3.00 to 4.50 per cent.
Sulphur, . .	from 0.03 to 0.06 per cent.
Phosphorus, .	from 0.04 to 0.07 per cent.

When the steel produced is to be submitted to particularly severe tests it is better to use a pig iron as devoid as possible of sulphur and phosphorus.

The sands necessary for making molds are silicious sands, containing a sufficient proportion of alumina to give the molds the required hardness. We do not give any analysis, because we have generally found suitable natural sands in all the countries where we have erected our steel plants. Anyhow it is possible

to obtain what is required by a judicious mixture of the different kinds of sands available.

All machinery castings having to be machined upon several faces must be cast in dried molds, also large castings with great thicknesses. Less important castings, for which slight defects, such as pinholes, slight scales, etc., are not a cause of rejection, are cast in green sand molds not dried. In the majority of foundries using our process a great proportion of the castings are cast in green sand molds not dried or merely skin dried. The greater part of the small castings are cast in the same manner.

The steel as it comes from the converter is perfectly soft and malleable. The great majority of castings delivered to the trade are neither reheated nor annealed. When pieces, however, have great or uneven thicknesses, or when they are of a great bulk, it is preferable to reheat them for a few hours at a cherry red heat in an ordinary furnace, without the use of any iron ore or other recarbonizing elements. The object of such a reheating is simply to transform the crystalline structure of pieces having great thicknesses into a finer grain, or to remove the molecular tensions due to the considerable shrinkage of steel when the castings have a great bulk. Reheating is also necessary when high mechanical results are to be obtained, and principally when a great elongation is required.

The installation of the steel process proper requires first, one or several converters, according to the quantity of steel to be produced. Each converter works in connection with a cupola; the latter is generally placed upon a metallic platform, high enough to allow the melted pig iron to run direct from the cupola into the converter.

The air blast for the converter can be produced by means of a rotary positive-pressure blower, the air pressure being only from 3 to 4 pounds per square inch. The quantity of compressed air required is from 22 to 25 cubic meters per minute (776 to 883 cubic feet) per ton of pig iron to be treated.

The expenditure necessary for a plant consisting of two 1-ton converters, two cupolas and their platforms, fans and rotary positive-pressure blower, is about $6,500, erection included.

The cost of two 2 ton converters, two cupolas, platforms, fans and blower is about $8,500, erection included.

To this must be added the cost of a crucible furnace for final additions, which we generally add in a melted state. The expenditure for such a furnace is a small one, and does not exceed from $150 to $200. Besides the steel producing plant proper, the usual foundry apparatus are necessary.

The operation on each charge in the converter lasts from fifteen to twenty minutes; some time is required for pouring the steel into the molds, and for preparing the converter for another blow. We reckon, when small pieces are manufactured and the whole charge has to be poured by means of hand ladles, that forty minutes are necessary for a complete operation. When the pouring is made with large ladles it requires only thirty minutes.

The converter lining lasts from 125 to 150 operations; the tuyeres from 30 to 40 operations, after which the latter must be replaced. While this is being done the necessary patching up of the lining is made according to requirements. If some holes have been formed they can be plugged by means of a mixture of cement and brick.

The linings are made with silica bricks, the cement being composed of quartz, sand and clay.

The cost of producing the steel varies from $5 to $6 per ton of 2,200 pounds over and above the cost of pig iron; this includes all expenses incurred at the blowing apparatus, cupolas, labor, lining, tuyeres and all general expenses for the manufacture of the steel in the ladle ready to pour.

Our steel being very hot and very liquid, it is easy to cast all kinds of small pieces very thin, and this is done without loss of metal.

Our process is perfectly suited for all these requirements, because of the great advantage it offers of being able to take from the converter small quantities of steel, exactly what is required for filling mold, then to tap the vessel again for the quantity of steel necessary for another casting, and so on. With our process we can, without any inconvenience whatever, cast very large

pieces in a practical manner and still remain well adapted for producing average and small castings. We very often run in the same ladle three, four and five successive melts, and use the total melt to cast one piece, and this we do without any loss of material from ladle-bottom skull, etc. Our steel is so hot and so fluid that it can be kept very long in a ladle without becoming pasty.

Lastly, our castings of ordinary soft quality weld as easily as iron, and they can be welded together or to iron exactly as the best soft steels produced so far by the basic processes.

PROTECTION OF STEAM-HEATED SURFACES.*

By Charles L. Norton.

The investigation, of which this is a partial report, has been undertaken at the request of Mr. Edward Atkinson, and has been pursued during a large part of the years 1896 and 1897, and is yet uncompleted. The first object sought for was the relative efficiency of several kinds of steam-pipe covering now upon the market. The second object was to ascertain the fire risk attendant upon the use of certain methods and materials used for insulation of steam pipes. Third, an attempt was made to show the gain in economy attendant upon the increase of thickness of coverings and to show also the exact financial return which may be expected from a given outlay for covering steam pipes. Further information is given on many minor matters and conditions affecting the transfer of heat from a steam pipe to the surrounding air.

Method.—The method adopted is one which, so far as I know, is original. A piece of steam pipe is heated from the inside electrically. The amount of electrical energy supplied is measured, and hence the amount of heat furnished is known. If the steam pipe is kept at a constant temperature by a given amount of heat, it is because that amount is just equal to the heat it is losing, for if the supply were not equal to the loss, the temperature would rise or fall. In other words, the heat put into the pipe is just equal to the heat lost from it by radiation, convection and conduction. By measuring the electrical energy supplied, I can determine the heat put in, and hence the heat given out or lost. It must be borne in mind that a given amount of electrical

* Paper read before the American Society of Mechanical Engineers at the Niagara Falls meeting.

energy always produces the same definite amount of heat, the amount of heat furnished by one electrical unit of energy being known with greater accuracy than the amount of heat given out by a pound of steam in condensing.

Apparatus.—The apparatus for making tests by this method comprises several pieces of steam pipe of different diameters and lengths, heated electrically from within by means of coils of wire in oil. The oil is stirred vigorously and serves as a very efficient carrier of heat from the wires to the pipes. A brief description of the smallest tester may make the details of the apparatus more easily understood.

A piece of 4-inch steam pipe, 18 inches long, is closed at one end by a plate welded in, and at the other by a tightly-fitting cover. This pipe is then filled with cylinder oil, and a coil of wire of sufficient carrying capacity and a stirrer are introduced into the oil. A thermometer is inserted in such a position as to record the temperature of the oil. An ammeter and voltmeter, or a wattmeter, may then be connected so as to record the amount of electrical energy supplied. The stirring must be brisk, and if enough power is put into the stirrer to be comparable with the electrical energy supplied, such amount must, of course, be added, as it also is converted into heat. It is my custom to suspend the apparatus in the middle of the room on non-conducting cords, and read the thermometer with a telescope, so that no heat from the person of the observer may be added to the supply given to the cover from within, and also that care may be taken not to produce air currents by walking near the apparatus during a test.

Procedure.—In making a test the following operations are carried out and observations are taken in the following order:

The current is turned on and heat is generated in the wire coil until the wire, oil and steam pipe have reached the desired temperature at which it is proposed to test. The current is then gradually diminished until it is found to be of just the amount necessary to keep the pipe at this temperature without a rise or fall of $\frac{1}{10}$ of a degree in thirty minutes. A reading of the voltage and current is now taken at intervals of 30 seconds, and the

watts and B.T.U. are computed from their average. We then have the number of B.T.U. lost from the outside of this particular pipe at this particular temperature. If now we place a steam-pipe cover around the pipe, we shall find that a less amount of energy is sufficient to keep it at the required temperature, the difference being the amount of heat saved by the covering. The minimum length of time considered sufficient for the equalization of heat or "soaking in" to the cover is six hours. If after a second heating of six hours no change in the conducting power is noted, the cover is considered in a permanent condition and is tested. Some covers, notably those composed wholly or in part of wool, cannot be considered dry and constant until after an exposure upon a pipe at 200 pounds pressure for six or eight days. Covers containing sulphate of lime are also slow in drying.

The three thermometers used were frequently standardized in naphthaline and were examined to note any disagreement among themselves.

A discussion of the position of the tester and its exposure to air currents will be found in a later paragraph.

Results.—A comparative test was made in 1895 upon a number of steam-pipe covers on a 4-inch tester, 16 inches long. The results obtained have been published in the circulars issued by the Boston Manufacturers Mutual Fire Insurance Company and by the Steam Users' Association. The values were stated to be purely relative, the specimen being too small to give reliable data on the absolute conduction, and the surrounding conditions not being controlled other than to maintain them constant during the several runs. The ends of the specimen were covered by massive heads, and the whole tester was situated within a few inches of a brick wall and a stone pier. It was called to my attention that the heat loss was probably high, and I agree that the exposure was such as to make it so, being a rather harsh test, but one which was rigidly uniform in its requirements of the several covers. In short, the actual loss of heat per square foot of the pipe surface was correct for that particular piece under the conditions of the test, but was not sufficient for the estimation of the actual saving which might be expected from the

general use of coverings. I deemed it wise, therefore, to construct new heaters, 4 and 10 inches in diameter and 36 inches long. These were suspended by non-conducting cords in the center of the laboratory, so as to hang freely and not be in contact with any conducting supports. Conduction up to the lead wires and stirring rod was found to be negligible.

It seems to me that I have approached more nearly the conditions of actual practice than can be obtained by any other method of testing, except the actual use of a long run of pipe, and the determination of the amount of heat put into such a pipe by the "condensation" method offers many difficulties and is open to much uncertainty. I feel, therefore, that in adopting this method I am using a reasonable exposure for the pipe and have an exceptionally good opportunity to measure the heat supplied.

Table I gives the relative conductivity of the various kinds of steam pipe cover tested up to April, 1898.

It gives the results of the tests upon most of the samples tested, some being omitted when found to be of such low efficiency as to be of doubtful value.

Specimen A consists of granulated cork pressed in a mold at high temperature, and then submitted to a fire-proofing process.

Specimen B is similar in composition, but is made up of several strips of cork instead of two semi-cylindrical sections.

Specimen C is a sectional cover composed of an inner jacket of earthy material and an outer jacket of wool felt, the whole being 1¼ inches thick.

Specimen D is a molded sectional cover composed of about 90 per cent. carbonate of magnesia.

Specimen E is essentially an air-cell cover, being composed of sheets of asbestos paper which has been indented before being laid up, the indentions serving to keep the thin sheets of paper from coming in close contact with one another, thereby causing a considerable amount of air to be held throughout the body of the cover.

Specimen F is composed of a wool felt with a lining of asbestos paper.

TABLE I.

Specimen.	Name.	B.T.U. Loss per square foot pipe surface per minute.	Ratio of loss to loss from bare pipe.	Thickness in inches.	Weight in ounces per foot of length, 4 inches diameter.
A	Nonpareil cork, standard	2.20	15.9	1.00	27
B	Nonpareil cork, octagonal	2.38	17.2	.80	16
C	Manville high pressure	2.38	17.2	1.25	54
D	Magnesia	2.45	17.7	1.12	35
E	Imperial asbestos	2.49	18.0	1.12	45
F	W.B.	2.62	18.9	1.12	59
G	Asbestos air cell	2.77	20.0	1.12	35
H	Manville infusorial earth	2.80	20.2	1.50	...
I	Manville low pressure	2.87	20.7	1.25	...
J	Manville magnesia-asbestos	2.88	20.8	1.50	65
K	Magnabestos	2.91	21.0	1.12	48
L	Molded sectional	3.00	21.7	1.12	41
M	Marsden infusorial earth	3.11	22.5	1.00	50
N	Marsden infusorial earth	3.27	23.7	1.00	43
O	Asbestos fire board	3.33	24.1	1.12	35
P	Calcite	3.61	26.1	1.12	66
	Bare pipe	13.84	100	...	...

Specimen G is a cover made up of thin sheets of asbestos paper fluted or corrugated and stuck together with silicate of soda.

Specimen H is a plastic covering made of infusorial earth.

Specimen I is a low-pressure covering similar to Specimen F.

Specimen J is a plastic cover, and called by the makers magnesia-asbestos. It contains only a slight amount of carbonate of magnesia.

Specimen K.—The magnabestos is a molded cover, containing about 45 per cent. of carbonate of magnesia and a considerable percentage of carbonate of lime.

Specimen L is composed mainly of sulphate of lime and some 20 per cent. of carbonate of magnesia and has upon its outer surface a thick sheet of felt board.

Specimen M is a sectional molded cover. It is composed largely of infusorial earth from California.

Specimen N is similar to Specimen M, except that to its composition has been added some 45 per cent. of carbonate of magnesia.

Specimen O is similar to specimen G, except that it has larger cells and contains much more silicate of soda. It is very hard and strong.

Specimen P is a sectional molded cover, composed mainly of sulphate of calcium. It has an outer layer of felt board.

In regard to the compositions of Specimens C, J, L and P, I desire to state that I have made no complete analysis, but have satisfied myself that the principal ingredient is sulphate of calcium and not carbonate of magnesia. Prospective purchasers of pipe covers should not be misled by names. Since the appearance of Professor Ordway's reports, it has been recognized that carbonate of magnesia was of great value as a non-conductor of heat, hence the name "magnesia" has been applied to a great many covers. It is to be observed that there is no virtue in a name.

TABLE II.

Specimen.	Percentage composition.	
	$MgCO_3$.	$CaSO_4$.
D	80 to 90	3
C	less than 5	65 to 75
L	20 to 25	50 to 60
P	less than 5	75
J	10 to 15	none.

Asbestos is merely an incombustible material in which air may be entrapped, but when not porous is a good conductor of heat. Magnesia is a most effective non-conductor. This name has been applied to many compounds of which the greater part consist of carbonate of lime, or plaster of paris, materials which are not good as a heat retardent. The percentage of magnesia carbonate

and plaster of paris in several molded sectional covers is given in Table II.

I have made no investigation of the effect of the raw materials upon the metal of the pipe, other than to satisfy myself that the cork, magnesia, air cell, and Imperial covers cause no corrosion.

The conditions of testing were such as I have adopted as being reasonably near the conditions of actual practice. The room temperature was kept at 72 degrees Fahrenheit, and the openings into the room were carefully closed. It was found early in the series that variation in the amount of moisture present in the air altered the amount of heat lost from the covers, but no attempt was made to correct for this. The error introduced is not greater than 1 per cent.

It was found that the heat loss per square inch of the flat surfaces at the ends of the pipes was less by several per cent. than the loss from the sharply curved sides, and as all pipe covers tested were used to cover both sides and ends, the figures given in the table show a loss less than would be shown were the pipe surface wholly cylindrical, and more than if it were all flat.

The pipes were suspended from the ceiling, as described in an early paragraph, and the air circulating about them was due only to their own convection currents. The variation in thickness in different places on the same specimen was considerable, but an average of twenty measurements was taken and results given in the table to the nearest $\frac{1}{8}$ of an inch. Owing to these variations in thickness, the results of a measurement of the efficiency of any one cover cannot be used to predict the efficiency of a second cover of the same make with an accuracy greater than 2 per cent. Two specimens of each make were tested, and in some cases four, the mean value being given in the table.

Table III gives the saving, in dollars, due to the use of the various covers.

Table IV shows that at the end of 10 years the best of the covers tested will have saved $46 more than the poorest. The difference between the several covers of the better grade is exceedingly small.

The money saving is computed on the following assumptions:

Coal at $4 a ton evaporates ten pounds of water per pound of coal. The pipes are kept hot 10 hours a day, 310 days a year. If computations are made, as is sometimes done, on an assumption that the pipes are hot 24 hours a day 365 days in a year, the saving is nearly three times that shown in Table III.

Generally speaking, a cover saves heat enough to pay for itself in a little less than a year, at 310 10-hour days, and in about four months at 365 24-hour days.

TABLE III.

Specimen.	Name.	Loss, B.T.U., 200 pounds.	Saving, B.T.U.	Saving per year per 100 square feet.
A	Nonpariel cork standard	2.20	11.64	$37.80
B	Nonpariel cork octagonal	2.38	11.46	37.20
C	Manville sectional H.P.	2.38	11.46	37.20
D	Magnesia	2.45	11.39	36.90
E	Imperial asbestos	2.49	11.35	36.80
F	"W. B."	2.62	11.22	36.40
G	Asbestos air cell	2.77	11.07	36.00
H	Manville infusorial earth	2.80	11.04	35.85
I	Manville low pressure	2.87	10.97	35.65
J	Manville magnesia-asbestos	2.88	10.96	35.60
K	Magnabestos	2.91	10.93	35.50
L	Molded sectional	3.00	10.84	35.20
M	Marsden, No. 2	3.11	10.73	34.85
N	Marsden, No. 1	3.27	10.57	34.60
O	Asbestos fire board	3.33	10.51	34.20
P	Calcite	3.61	10.23	33.24
	Bare pipe	13.84	0.00	...

It is evident that the decision as to the choice of cover must come from other considerations as well as from the conductivity.

The question of the ability of a pipe cover to withstand the action of heat for a prolonged period without being destroyed or rendered less efficient is of vital importance. The increasing use of cork as an insulator has led to many questions as to its ability to remain "fireproof." I have exposed it to a temperature corresponding to 350 pounds of steam for three months,

and to a temperature corresponding to 100 pounds for two years, and can detect no change, and I am satisfied, as well as one can be without the actual experience, that any suspicion of its ability to withstand continued heating is groundless.

TABLE IV.—NET SAVING PER 100 SQUARE FEET.

Specimen.	Name.	One year.	Two years.	Five years.	Ten years.
A	Nonpareil cork standard	$12.80	$50.60	$164.00	$353.00
B	Nonpareil cork octagonal	12.20	49.40	161.00	347.00
C	Manville sectional, high pressure	12.20	49.40	161.00	347.00
D	Magnesia	11.90	48.80	159.50	344.00
E	Imperial asbestos	11.80	48.60	159.00	343.00
F	"W. B."	11.40	47.80	157.00	339.00
G	Asbestos air cell	11.00	47.00	155.00	335.00
H	Manville infusorial earth	10.85	46.70	154.25	333.00
I	Manville low pressure	10.65	46.30	153.75	331.00
J	Manville magnesia-asbestos	10.60	46.20	153.00	331.00
K	Magnabestos	10.50	46.00	152.50	330.00
L	Watson's molded sectional	10.20	45.40	151.00	327.00
M	Marsden, No. 2	9.85	44.70	149.20	323.00
N	Marsden, No. 1	9.60	44.20	148.00	321.00
O	Asbestos fire board	9.20	43.40	146.00	317.00
P	Calcite	8.24	41.48	141.20	307.00
Q	Bare pipe	...	...	...	...

The magnesia covering is, of course, unquestionable on this ground, being almost indestructible by heating.

The Imperial asbestos is also perfectly safe from any fire risks, as is the air cell and fire board.

The Manville and Marsden infusorial earth, and also the Manville asbestos-magnesia, are liable to no accident from fire, nor is the Carey calcite.

It is to those covers, the "W. B." of the Watson Company, and the Manville sectional and others which possess a composite structure that I desire to call attention. I do not consider it safe to put upon a steam pipe wool, hair felt or woolen felt in any form. The causes of risk are two: First, the wool may become charred by heat from the pipe and finally ignited. However, this can hardly happen, even on high-pressure pipes, when the thickness of fireproof material, asbestos, magnesia or

whatever it may be, is of as great a thickness as one inch. The second, and most serious risk, is from the presence in shops or mills of the long tubes of wool, dry as tinder, often connecting one room with another, and ready to flash at the slightest rise in the already too great temperature. I would even insist that the canvas jackets on the covers be fireproof. An accident in my own laboratory has proved the actual danger of these wool felts, and I should not be willing to allow their use again. Their efficiency is high as non-conductors, but not higher than any other perfectly safe covers. If the wool is separated by about one inch of fire-proof material from the pipe, it is not kept so hot and dry, and the risk from outside ignition is less, but I do not indorse the practice of many engineers in wrapping hair felt outside of a sectional cover. The saving due to this practice is indicated in Table V.

The following assumptions have been made in computing the Tables IV, V and VI. First, that all the covers cost $25 per 100 square feet applied. I realize this is a high figure, perhaps too high, yet it is not far from the list price of several makers, and any attempt to get a definite price from them revealed a maze of discounts and double discounts and flexible price lists too intricate for an uninitiated mind to travel. In case the saving due to a cover which costs $20 instead of $25 is desired, the simple addition to the final saving of the $5 difference makes the necessary correction.

Secondly, by the advice of the makers, I have made an assumption that the cost is not nearly proportional to the thickness. As the thicker coverings are not now made in great quantities, the actual cost of their manufacture is uncertain.

Inspection of Table V shows the saving due to the use of hair felt outside a standard magnesia cover.

In five years 100 square feet of hair felt saves $7 more than its cost, and in ten years it saves $20 above its cost.

The further saving due to a second inch outside the first is $8 in ten years. Of course the well-known tendency of hair felt to deteriorate should be considered.

In the case of nonpareil cork, increasing the thickness from

one to two inches raises the cost from about $25 to $35 per 100 square feet, and increases the net saving in five years by $10 and by $30 in ten years. In other words, the second inch of material in use about pays for itself in two years, while the first pays for itself in about one year. The third inch does not increase the saving even in ten years. The second inch, therefore, more than pays for interest and depreciation, while the third fails to do this.

In the case of the asbestos fire board, a second inch in thickness causes a saving of $20 in ten years, the third and fourth inches showing a loss.

In general it may be said, therefore, that if five years is the length of life of a cover, one inch is the most economical thickness, while a cover which has a life of ten years may, to advantage, be made two inches thick.

TABLE V.—VARIATIONS IN THICKNESS, ETC.

Specimen.	Saving in B.T.U. per square foot per minute.	Saving in dollars per 100 square feet per year.	Net saving.				Approximate cost.
			One year.	Two years.	Five years.	Ten years.	
Magnesia:							
1⅛-inch thick	11.62	$37.75	$7.75	$45.50	$159	$347	$30
Magnesia, 1⅛ inch thick, and 1 inch hair felt	12.38	40.22	5.22	45.44	166	367	35
Magnesia, 1⅛-inch thick, and 2 inches hair felt.	12.77	41.50	1.50	43.00	167	375	40
Nonpareil cork:							
1 inch	11.64	37.80	12.80	50.60	164	353	25
2 inches	12.84	41.75	7.75	48.50	174	383	35
3 inches	12.94	42.05	7.95	34.10	160	370	50
Fire board:							
1 inch	10.54	34.20	9.20	43.40	146	317	25
2 inches	11.48	37.25	2.25	39.50	151	337	35
3 inches	11.70	38.00	12.00	26.00	140	330	50
4 inches	11.83	38.40	20.60	11.80	127	319	65

In view of the custom which prevails to some extent of wrapping asbestos paper around a pipe, and surrounding the whole with hair felt, I made tests as to the temperature of the bound-

ing line of the asbestos paper and hair felt, using a Le Chatelier thermo-electric pyrometer for this purpose. The different samples of asbestos paper give widely varying results, but a general idea of the protection afforded by the paper may be had from Table VI.

TABLE VI.—PROTECTION AFFORDED BY ASBESTOS-PAPER: PIPE AT 200 POUNDS PRESSURE.

Thickness of Asbestos paper.	Temperature of pipe.	Temperature of inside of hair felt.	Pressure corresponding to the temperature of the inside of the hair felt.
inch.	*deg. Fahr.*	*deg. Fahr.*	*pounds.*
$\frac{1}{64}$	384.7	356	146
$\frac{1}{32}$	385.0	329	102
$\frac{1}{16}$	384.6	302	70
$\frac{1}{8}$	384.7	266	39

I have had my attention called to the varying loss from bare pipes when their surfaces were in varying conditions as regard rust, dirt, paint, etc. I therefore made a few brief tests to satisfy my mind as to the chance of there being any large variation which might influence my figure for the loss from bare pipe, viz., 13.84 B.T.U. per square foot per minute. The results are shown in Table VII.

TABLE VII.—LOSS OF HEAT AT 200 POUNDS FROM BARE PIPE.

Condition of specimen.	B.T.U. lost per square foot per minute.
New pipe	11.96
Fair condition	13.84
Rusty and black	14.20
Cleaned with caustic potash inside and out	13.85
Painted dull white	14.30
Painted glossy white	12.02
Cleaned with potash again	13.84
Coated with cylinder oil	13.90
Painted dull black	14.40
Painted glossy black	12.10

The rate of heat loss from a bare pipe is also affected by the air circulation and the temperature of the surrounding bodies. A few tests were made to indicate the magnitude of the errors likely to be caused by variation in these conditions, and a brief examination of some of the results may be interesting. They are given in Table VIII.

TABLE VIII.—EFFECT OF SURROUNDINGS.

Condition and position of pipe.	B.T.U. lost per square foot per minute at 200 pounds.
1. Standard condition hung in center of room	13.84
2. Near brick wall, between windows	14.26
3. Hung horizontally in center of room	12.06
4. Vertical 10-inch pipe { 36 inches long	13.48
{ 18 inches long	14.42
5. Vertical, 18 inches long { 10 inches diameter	14.42
{ 4 inches diameter	15.20
6. 4 inches diameter in draft from electric fan	20.10

Table IX shows the varying loss from a bare pipe with the change in pressure:

TABLE IX.—VARIATION OF HEAT LOSS WITH PRESSURE.

Pressure.	Bare pipe, loss B.T.U. per square foot per minute.
340	15.97
200	13.84
100	8.92
80	8.04
60	7.00
40	5.74

A very thorough test was made of the common method of judging a pipe cover by the sensation of warmth given the hand on touching it, and nothing too harsh can be said of this practice. The sensation is dependent to such an extent upon the nature of the surface that it fails utterly to give any idea of the

actual temperature. I have been unable to devise any method of so attaching a mercury thermometer to the outside of a steam pipe cover as to make use of it as a testing device in measuring heat loss.

I am desirous of calling attention to the advantages arising from the use of plastic rather than sectional covers. The ease of removal for repairs or alterations makes the sectional cover better for some work, but there is much pipe surface which might be covered securely with plastic where a sectional cover is soon ruined by vibration. Of course the plastic covers offer no possibility of leaky joints and long cracks. It should be borne in mind that in most cases about 20 per cent. of the entire surface to be covered is irregular, and must be covered by plastic or fittings. It will be well for prospective purchasers of pipe cover to see to it that their contracts call for fittings and plastic of as high an efficiency as the sectional cover shows.

I am now testing a considerable number of samples of non-conducting material, not perhaps classed as pipe covers, but used for heat insulation. Table X gives some figures concerning them which may be of interest.

TABLE X.—MISCELLANEOUS SUBSTANCES.

Specimen.	B.T.U. per square foot per minute at 200 pounds.	Saving in one year per 100 square feet pipe.
Box A:		
1 with sand	3.18	$34.60
2 with cork powdered	1.75	39.40
3 with cork and infusorial earth	1.90	38.90
4 with sawdust	2.15	37.90
5 with charcoal	2.00	38.50
6 with ashes	2.46	36.90
Brick wall, 4 inches thick	5.17	28.80
Pine wood, 1 inch thick	3.56	33.80
Hair felt, 1 inch thick	2.51	36.80
Cabot's seaweed quilt	2.78	35.90
Spruce, 1 inch thick	3.40	33.90
Spruce, 2 inches thick	2.31	37.50
Spruce, 3 inches thick	2.02	38.50
Oak, 1 inch thick	3.65	33.10
Hard pine, 1 inch thick	3.72	32.90

The box A referred to in the table is a $\frac{7}{8}$-inch pine box, large enough to surround the pipe, and leave a one-inch minimum space at its four sides. In it were tested several materials which I find are used in just this way for steam and cold storage insulation.

In concluding, I desire to express my thanks to those gentlemen who have assisted me in this test, and especially to Mr. John R. Freeman, member of the Society, for his kindly advice.

THE PROBLEM OF COMBUSTION IN WATER-TUBE BOILERS, AND A MEANS OF ITS SOLUTION.

[A paper by MR. JAMES WEIR, read before the Sheffield meeting of the Institution of Engineers and Shipbuilders in Scotland, June, 1898.]

In adding one more to the already large number of contributions to the literature of the water-tube boiler, the writer calls to mind the statement of an eminent authority on a somewhat different matter, that "it requires a considerable amount of ignorance to speak positively on such a subject." It will, however, be a necessity to speak positively on various points, but, as a corrective in so doing, an endeavor will be made to appeal to the experience of engineers familiar with the types and performances of boilers generally, as the purpose of this paper is practically an application of that experience to new and hitherto unfamiliar conditions.

For a considerable time past, the engineering world has been inundated with designs of new water-tube boilers. Whole families of these boilers have been born, supporting the doctrine of heredity in an unmistakable manner. Phenomenal results have been tabulated and given forth; advantages of many kinds have been claimed, but to all these the great mass of engineering opinion in this country, while conceding here and there a point, has been, on the whole, inert and unresponsive. In particular, the merchant marine, which is always eager to seize on any engineering development likely to affect its balance sheet, has held strangely aloof, and has not yet been, to use the expression of a distinguished Scotsman lost to engineering, "battered into acquiescence" on the subject of water-tube boilers.

Exception to the above statement must, of course, be made in the case of the Navy, where, however, the requirements are of a different nature from those which obtain in the mercantile

marine, and in ordinary industrial spheres. Granting the requirements to be to some extent abnormal, nevertheless, we find that many of the advantages claimed for water-tube boilers are such as, other things being equal, should commend their adoption generally where boiler plant is in use. Their capability for the development of high pressure on a comparatively small weight, their rapidity in raising steam, their ease of transport and erection, all appeal to the commercial sense, upon which, after all, engineering opinion is founded. Why is it then, that, with this mass of evidence in its favor, the water-tube boiler has not been more rapidly and more generally adopted in the mercantile marine?

Firstly, it may be said, it is on account of the character of the evidence, so far as trials and results are concerned. A pound of coal burned in a boiler is capable of producing a certain definite number of units of heat, depending upon its composition and quality, and for any particular boiler the method of burning and the arrangement most suitable for utilizing the heat has to be found. When, therefore, we have found these for a particular boiler, we can, on trial, get as good a result from one boiler as from any other. This is a fact which must be taken into account when considering the high results which have been published of the performances of water-tube boilers; because these results have been obtained by the most careful manipulation, and under the most favorable conditions, specially studied and arranged for the boiler under trial. That such results have been obtained, and can be obtained, is not questioned, but the point is that they have been obtained under conditions and by attention which are quite outside the range of everyday working. It is not on exhibition results of this kind that the commercial man, looking for some improvement in his boiler plant, bases his calculations and forms his opinion, but on lengthy and continuous trials under the actual conditions of his work.

Secondly, leaving aside all considerations of design, we may state broadly that low efficiency on continuous working is the next feature which has chiefly militated against the adoption of the water-tube boiler. This is specially the case in the mercan-

tile marine, where continuous economical working is a primary necessity.

In seeking the season for this, the common failing of water-tube boilers, we will consider first of all the conditions which must be fulfilled in boilers not of the water-tube type, in order to give good results, conditions which experience has made familiar to most engineers. We may say that, to make a good steam boiler, the following points must have attention:

1. Good combustion must be obtained.
2. The heating surface must be sufficient to take up the heat.

Taking the first point, if we examine how the combustion is carried out in the most economical boilers, we find that, in all boilers which give good results, the combustion is carried out in the same manner. As a typical example, we shall take the marine return-tube boiler. Here we have, first, the furnace, in which the coal is burned and the inflammable gases produced. Next, we have the bridge, over which the gases pass together with the air, either admitted at the front or through the grate near the bridge, generally at both places. The function of the bridge is to reduce the opening through which the gases and the air must pass into the combustion chamber. The effect of reducing the opening is to accelerate the speed of the gases passing through the opening, with the result that, when they enter the large space behind the bridge, eddies and whirling motions are set up which thoroughly mix the air and gases, and combustion is the result. Next we have this space behind the bridge, namely, the combustion chamber, in which the gases are burned.

To obtain good results, it is absolutely necessary that both the furnace and combustion chambers should be properly arranged; the furnace must have sufficient room above and below the fire grate, and the combustion chamber must be large enough to deal with the volume of gases passing through it. Nevertheless, with a well-proportioned furnace and a sufficiently large combustion chamber, good results will not be obtained unless the bridge opening or passage between them be properly arranged. This point need scarcely be further insisted upon, as it

is a well-known fact that the efficiency of every boiler depends a great deal on the proper proportion and arrangement of bridge and combustion chamber.

If we wish to test the effect of modifying the bridge and combustion chamber in one of those economical boilers, let us, for example, refer to the boilers shown in Figs. 1, 2 and 3 on the opposite page. In Fig. 1 we have the grate bars carried right back into the combustion chamber, with the bridge wall at the back. In this case, the combustion chamber is, for all practical purposes, converted into a flue for leading the air and gases to the tubes. The effect of this construction is that the air and gases do not mix at all until they reach the uptake, where combustion will take place if they become ignited. When the fuel is consumed in this manner we may expect to burn, in ordinary working conditions, say 2 pounds of coal per I.H.P. per hour. By simply shifting the bridge wall forward into the furnace, as in Fig. 2, the air and gases passing through the narrow opening over the bridge wall will have their speed accelerated, and when they enter the large open space mixing will take place, and the better they are mixed the more complete will be the combustion. With conditions similar to those in the first case, but with this alteration on the bridge wall, we may expect to burn 1.6 pounds of coal per I.H.P. per hour.

In Fig. 3, we have again increased the size of the combustion chamber by curtailing the length of the grate, and under the same conditions as in the previous case we will only burn 1.4 pounds per I.H.P. per hour. Various explanations have been given to account for this result, but these need not be detailed. The writer is of opinion that the correct reason is to be found in the increased size of the combustion chamber, and the manner in which the air and gases are practically tumbled over the bridge, so as to mix and ignite before passing through the heating tubes.

In all economical types of land boilers, as for example, the Lancashire boiler, the combustion is carried out in exactly the same way as described, and the means are also similar, namely, the furnace, the bridge and the combustion chamber, the latter

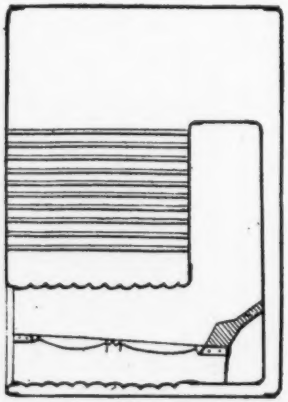


FIG. 1.

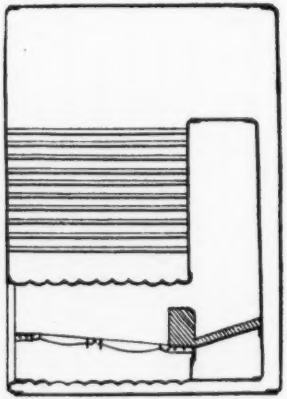


FIG 2.

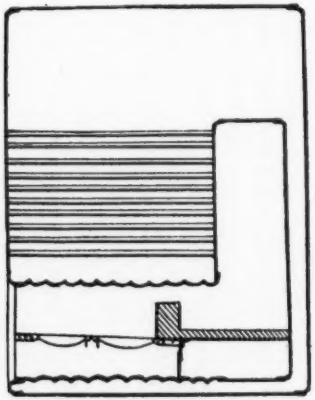


FIG. 3.

being in a line horizontal with the furnace instead of vertical, as in the case of the marine return-tube boiler. We have still a fairly economical boiler in the locomotive type, on railway work, and in it also we find the same features reproduced, the bridge which divides the fire box providing the combustion chamber over the furnace.

Let us next consider the second point, namely, the heating surface. It may safely be said that all good water-tube boilers of whatever type have sufficient heating surface, though in some the heating surface is more efficient than in others. The value of the heating surface in all boilers depends on the uniform passages of the gases over or in contact with it. Now, in most water-tube boilers we find that the area between the tubes is too great, and the result is the same as making the area through the tubes too great in a return-tube boiler. This would be a recognized defect in an ordinary boiler, but in one of the water-tube type, to remedy this alone would scarcely add anything to the efficiency, as it is a primary defect which must be rectified before the gases meet the tubes.

It will be instructive if we now consider for a moment the combustion in the case of water-tube boilers generally. In practically all water-tube boilers the process of burning the coal and gases is carried out in a single chamber, namely, the furnace. In some boilers the space over the furnace is large, with a view to utilizing it as a combustion chamber. Now, this large space over the fire is intended to do the duty of mixing the air and gases, so that they may combine and burn, but to do this it must receive the air equally all over the fire through the grate. For the purpose of attaining this in even an ordinary measure, great care and training on the part of the stokers is necessary, as every increase or diminution in the rate of steaming or the size of the coal makes an increase or diminution in the thickness of fire necessary. If by careful stoking the mixing and combustion of the air and gases be actually attained, the temperature of the furnace will be equal to that of a well-designed puddling furnace, with the result that the boiler is subjected to conditions far more severe than those under which any ordinary

good type of boiler ever works, or should work. It is worse than useless to admit air at the back, front or sides of the furnace, as it will not mix with the gases, but simply shape its course straight for the nearest passage between the tubes to the funnel, and set fire to the gases there if they are sufficiently hot to ignite.

In water-tube boilers of another type, where it has evidently been found to be a difficult matter to let the proper quantity of air through the grate, air-compressing pumps are employed to throw jets of air over the fires, and so bring about the mixture with the combustible gases. Even with these appliances, and with trained stokers, the danger of converting the uptake into a combustion chamber is considerable. There is one important lesson, however, to be learned from combustion as it occurs in existing water-tube boilers, namely, that the tubes will stand this enormous heat generated in contact, and even although complete combustion is not attained, the temperature in this type is much higher than is ever attained in an ordinary furnace or combustion chamber.

We have now considered the reason of the low efficiency in water-tube boilers, and we have also found, in ascertaining the properties which secure efficiency, that there is a common property of all economical boilers which is absent in that of the water-tube type, namely, efficient combustion. We are, therefore, led to ask, Can we not, by adopting similar means in a water-tube boiler, bring about a similar efficiency to that obtained in those economical types of boilers?

This the writer has endeavored to do, and he submits the "Weir" water-tube boiler as the practical answer to this question. It consists, like many other water-tube boilers, of an upper steam drum and a lower water drum or drums, connected by tubes, but differentiated from others by the arrangement of a secondary combustion chamber *A* between the tubes, having an inlet and outlet so arranged as to effect the complete admixture of the air and gases, and thus obtain combustion before passing over the major portion of the heating surface of the boiler. In this boiler the writer has endeavored to reproduce the phenomena of com-

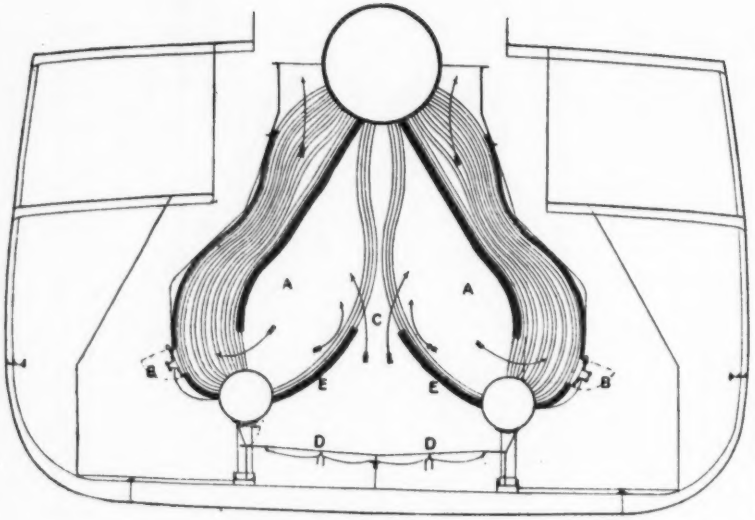


FIG. 4.

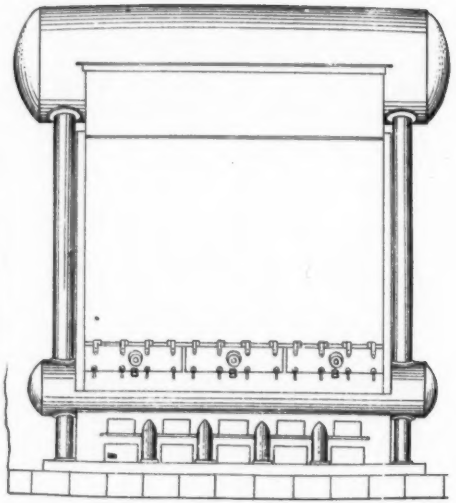


FIG 5.

bustion in the same manner as these phenomena occur in the best marine return-tube boiler, and after continuous trial he feels justified in submitting this arrangement as a solution of the problem of combustion in water-tube boilers.

In this paper it is not intended to describe the details of the boiler, but merely the evolution of the leading feature of the design, and accordingly it has been considered sufficient to give only one form of the boiler in illustration.

Figs. 4 and 5 show the arrangement of a boiler suitable for a light-draught channel steamer. It can, however, be adapted for practically any requirements, land or marine. In all cases the combustion is carried out as in the marine return-tube boiler, and it is fired in exactly the same way. It has, however, this advantage, that the stoker can look into the combustion chamber, *A*, through an aperture, *B*, provided for this purpose, and from the color of the flame at the bridge opening, *C*, he can see if the necessary amount of air is being admitted, and if not, he can increase the supply by adjusting the opening of the furnace door. By this adjustment the gases can be effectually burned with the minimum amount of air, in order to suit any rate of steaming, condition of fire or quality of fuel. As a matter of actual practice, attention may be drawn to the fact that when the combustion chamber, *A*, is placed over and separated from the furnace, *D*, by the bridge wall, *E*, it has been found that the most effective place to admit the air is through the furnace door, and not at the back of the furnace, as is the case in most boilers. It may appear as if this were a departure from the arrangement in the marine return-tube boiler which we are endeavoring to reproduce, but a little consideration will show that it is analogous to that which obtains in that type. In this boiler the gases from the fire pass through below the bridge wall (*E*), the air passing over and between them and the wall. It will thus be seen that the only difference lies in the bridge wall not being inverted, thus accounting for the apparent dissimilarity.

In addition to this special feature, namely, the complete combustion of the fuel, other points of advantage might also be mentioned: the ease of feeding, which requires no more attention

than is necessary with a Scotch boiler, the independence of automatic complications, the general simplicity of construction, which enables the boiler to be made in large units of from 2,000 to 4,000 I.H.P., the ease of stoking, etc., but the scope of this paper does not permit these to be spoken of at length.

Having shown, however, the manner in which complete combustion is obtained in the "Weir" boiler, attention may be drawn to two most important results which follow thereon:

1. The complete absence of smoke.

2. The suitability of the boiler for burning practically any kind of coal, and giving good results.

The ease with which complete combustion is obtained, by regulating the air supply according to the color of the flame in the combustion chamber, has the effect of entirely preventing the production of smoke. In actual working without special care, the stoker an entirely untrained man, and using as fuel small bituminous coal, only a slight vapor can be seen to leave the chimney, and thick black smoke is entirely unknown. The importance of this advantage for power plants installed in thickly populated centers is so obvious as not to require insisting upon, and as it is obtained without expenditure in the shape of special stoking or blowing arrangements, but simply as a resultant effect of correct design, the gain is two-fold.

With regard to the second point, it is obtained by the same means as the first, and is practically a corollary of the first, and it is mentioned, not as a mere logical sequence, but as a result of actual everyday working. The different qualities of coal obtained abroad require the most careful consideration by the superintendents of the mercantile marine, and largely affect the earning power of vessels in various ways. A boiler, therefore, which is capable of taking the utmost out of any kind of coal, and that without any extra attention other than the observation of flame in the combustion chamber, has an advantage which is bound to affect most favorably the voyage account of any vessels so fitted.

Let us consider for a moment how the points which we have just mentioned are applicable to the needs of H. M. Navy. It is

unnecessary to point out the great importance, from a naval point of view, of preventing the emission of smoke. To secure this advantage the Admiralty have sacrified much in times past. They have adopted hand-picked Welsh coal as the standard coal for the Navy, considering it to be the most suitable for their purpose.

Conceding without question to the Belleville boiler, and to small tube boilers adopted by H. M. Navy, the various advantages which are claimed for them, it is submitted that on this single point of the production of smoke they are far from satisfactory. It is impossible to gainsay this, as it is common to the experience of every engineer who has been associated with the vessels of H. M. Navy fitted with these boilers, and observed their performances. These results, be it noted, are obtained when using Welsh coal, which, according to all experience, is least capable of producing smoke. In the adoption of water-tube boilers then, with their various advantages, the Admiralty have lost this advantage, one which hitherto they have endeavored to obtain at enormous cost, and one which, from a strategic point of view, is of the greatest importance.

With reference to the second point, the capability of this boiler for burning practically any kind of coal, reference has just been made to the expense to which the Admiralty have gone by the adoption of Welsh coal, and it may be pointed out that a great portion of this is entailed by the provision at the various naval bases abroad of adequate supplies of this coal. Attention has also been drawn in other quarters to the fact that in time of war the sphere of operations by the Navy will be, to a great extent, limited by the maintenance and quantity of these supplies. The adoption of water-tube boilers has greatly intensified this dependence, as it is a well-known fact that without the use of the best hand-picked Welsh coal the results of these boilers are, to say the least, disappointing, and many of the advantages—apart altogether from the smoke question—are absolutely discounted.

The coal endurance of a warship is a most important factor in her capabilities as an effective instrument of war; the advantage,

therefore, which any vessel possesses in being able to utilize, with good results, any class of coal obtainable at any quarter of the globe she may happen to be, must necessarily give her a vast superiority and greatly increase the range of her efficiency.

The Welsh coal strike and the operations of the Spanish-American war are both object lessons which indicate the dependence of a Navy fitted with water-tube boilers, not upon coal alone, but upon one particular kind of coal, and reveal to us a vulnerable point in our national armor.

These are a few of the questions affected by the solution of the problem which gives a title to this paper. It has been possible only to indicate them very briefly and in general terms, but it is hoped that their importance is none the less apparent.

It may appear unusual, after describing a means of obtaining economy, that greater stress has not been placed upon the economical results of the arrangement described, and it may seem an unwarrantable omission that no table of results is appended to this paper. A word of explanation as to why these results do not appear may therefore be necessary. Complete combustion of the fuel and the proper utilization of the heat produced, are necessary to obtain economy in a boiler. Hitherto the first condition has been wanting in water-tube boilers, and, as a necessary consequence, the second; the aim of this paper has been to show a means by which this complete combustion may be obtained. If this means be successful, and carry with it no disadvantages, then it may be inferred that the boiler will give economical results. It may at once be said emphatically that the means has proved entirely successful, and that the economy due to complete combustion has been obtained.

From the remarks made in a previous portion of the paper, however, it will be gathered that the trials carried out have not been on the ordinary basis, which makes possible comparison with published results of boilers worked under special conditions. To fully describe the trials, and present the results in such a manner as not to be misleading, would demand a paper of greater length than this, and to simply publish a table of results without explanation, while it would show the economy

obtained would not in itself show the measure of that economy. It has been deemed preferable, instead of taking a result obtained under the most favorable conditions and exhibiting it as a standard performance, rather, from principles understood and already in operation, to indicate the lines upon which these principles must be applied to a fresh set of conditions, leaving to the consideration of engineers generally, whether any points have been advanced in so doing, which their experience and judgment do not fully and completely sanction and support.

COST OF TRANSPORTATION ON THE LAKES.

[Reprinted from the "Marine Review."]

IN 1897 THE MILE-TON RATE WAS REDUCED TO 83-HUNDREDTHS OF A MILL. INTERESTING REPORT FROM ST. MARY'S FALLS CANAL OFFICIALS.

Again the cost of moving a ton of freight one mile on the lakes, as indicated by the St. Mary's Falls Canal Reports, prepared under the direction of Col. G. J. Lydecker, of the Army Engineer Corps, has been materially reduced. The office force of the United States Canal at Sault Ste. Marie has finished the report known as the "Mile-Ton Report." This report enters into numerous details regarding the traffic of both canals, Ca-

TABLE SHOWING THE ESTIMATED VALUE OF FREIGHT MOVED THROUGH ST. MARY'S FALLS CANAL, MICHIGAN, AND SAULT STE. MARIE CANAL, ONTARIO, FOR THE SEASON OF 1897.

Items.	Designation.	Quantity.	Price per unit.	Valuation.
Coal, anthracite	Net tons.	536,199	$5.50	$2,949,094.50
Coal, bituminous	Net tons.	2,502,973	2.60	6,507,729.80
Flour	Barrels.	8,921,143	4.50	40,145,143.50
Wheat	Bushels.	55,924,302	.87	48,654,142.74
Grain (other than wheat)	Bushels.	24,889,688	.46	11,449,256.48
Manufactured iron	Net tons.	121,848	50.00	6,092,400.00
Pig iron	Net tons.	13,316	13.25	176,437.00
Salt	Barrels.	285,449	.75	214,086.75
Copper	Net tons.	122,324	200.00	24,464,800.00
Iron ore	Net tons.	10,633,715	3.00	31,901,145.00
Lumber	M. ft. B.M.	805,612	13.50	10,875,762.00
Silver ore	Net tons.	5	112.00	560.00
Building stone	Net tons.	6,249	10.00	62,490.00
Unclassified freight	Net tons.	579,048	60.00	34,742,880.00
				218,235,927.77

Average value per ton of freight for season of 1896 = $12.02.
Average value per ton of freight for season of 1897 = $11.50.

nadian and United States, and will be submitted to Congress shortly, through the Secretary of War. It is found that the value of all freight moved through the canals in 1897 (18,982,755 net tons) was $218,235,927.77, against a total value of $159,575,-129.43 for 16,239,061 net tons of freight in 1896; and the cost per ton per mile in 1897 was 83-hundredths of a mill, against 99-hundredths in 1896. The increase in value of freight in 1897 is $58,660,798.34.

An exchange of official reports with Canadian canal officials makes this report a complete summary of commerce to and from Lake Superior, as was the case before the Canadian Canal was built. Where Canadian commerce is mentioned in the report, it means freight carried in Canadian bottoms, and has no reference to the canal through which the vessel passed or through which the freight was transported.

Relative values of the several principal commodities are shown in the following table:

	Per cent.
Coal,	4.3
Cereals,	45.9
Iron,	17.5
Copper,	11.2
Lumber,	5
All other products	16.1

In this summary both hard and soft coal are included under the head of "coal;" wheat, flour, grain other than wheat, under the head of "cereals;" iron ore, manufactured and pig iron, under the head of "iron." It will be observed that the "cereals" are far the most important in valuation, amounting to 45.9 per cent. of the whole. This is followed by "iron," with a valuation of 17.5 per cent.; copper, 11.2 per cent.; lumber, 5 per cent., and coal, 4.3 per cent. It will thus be seen that the five items enumerated above make up 83.9 per cent. of the entire value of freight moved through the canals.

The total cost of freight transportation in 1896 was $13,511,-615.80, and in 1897, $13,220,099.84. The nature of the data

COST OF CARRYING FREIGHT TRANSPORTED THROUGH ST. MARY'S FALLS CANAL, MICHIGAN, AND SAULT STE. MARIE CANAL, ONTARIO.

Items.	Unit.	Quantity.	Price per unit.	Amount.
Coal	Net tons.	3,039,172	$ .30	$911,751.60
Flour	Barrels.	8,921,143	.10	892,114.30
Wheat	Bushels.	55,924,302	.01 7/10	950,713.13
Grain (other than wheat)	Bushels.	24,889,688	.02	497,793.76
Manufactured iron	Net tons.	121,848	1.40	170,587.20
Pig iron	Net tons.	13,316	1.05	13,981.80
Salt	Barrels.	285,449	.15	42,817.35
Copper	Net tons.	122,324	1.95	238,531.80
Iron ore	Net tons.	10,633,715	.65	6,911,914.75
Lumber	M. ft. B.M.	805,612	1.55	1,248,698.60
Silver ore and bullion	Net tons.	5	2.33	11.65
Building stone	Net tons.	6,249	1.50	9,373.50
Miscellaneous merchandise	Net tons.	579,048	2.30	1,331,810.40
Total cost				13,220,099.84

Tons are net tons of 2,000 pounds.

By dividing the total amount of freight paid, $13,220,099.84, by the total mile-tons, 15,969,393,576, it is found that the cost per ton per mile is $\frac{83}{100}$ of a mill. The average distance freight was carried was 841.3 miles, which is 4.9 miles more than in 1896.

from which the preceding results were found is such that it includes the cost of loading and unloading. Other results were obtained as follows:

Total mile-tons,	15,969,393,576
Total freight paid,	$13,220,099.84
Cost per mile per ton, mill,	$\frac{83}{100}$
Average distance freight was carried, miles,	841.3
Average cost per ton for carrying freight, cents,	69.6

The number of registered craft which used the canal during the season was:

Steamers,	525
Sails,	323
Total,	848

AMERICAN CRAFT.

Class.	No.	Registered tonnage.	Freight tonnage.	Passengers.	Valuation.
Steamers	484	506,487	12,698,150	22,176	$33,963,100
Sails	303	250,651	5,702,610	51	8,412,600
Total	787	757,138	18,400,760	22,227	42,375,700

CANADIAN CRAFT.

Class.	No.	Registered tonnage.	Freight tonnage.	Passengers.	Valuation.
Steamers	41	21,377	465,517	17,986	$1,793,100
Sails	20	10,424	87,716	.....	208,300
Total	61	31,801	553,233	17,986	2,001,400

The total passages by unregistered craft when carrying freight was 377. The freight carried by American unregistered craft amounted to 9,560 tons in 185 passages, making an average of a trifle more than 51 tons of freight per passage. The freight carried by Canadian unregistered craft amounted to 19,202 tons in 192 passages, making an average of a trifle more than 100 tons of freight per passage.

SUMMARY.

Total number of registered craft,	848
Total passages by unregistered craft while carrying freight,	377
Total tons of freight carried by registered craft,	18,953,993
Total tons of freight carried by unregistered craft,	28,762
Total passengers,	40,213
Total valuation of craft registered,	$44,377,100

The Canadian freight amounted to 572,435 tons, which is 3 per cent. of the total freight for the season.

The passages for the season numbered 17,171, and 1,454 of these were by ninety craft under 100 tons register. The aggre-

gate registered tonnage of these ninety vessels was 2,599 tons, and their average tonnage 29 tons. The freight carried by these craft during the season amounted to only 2,181 tons.

From the column of largest cargoes it is ascertained that there were ninety-six steamers that carried in their largest load 2,000 tons and upwards; that these cargoes aggregated 244,061 tons and averaged 2,542 tons; there were eighty-three steamers that carried in their largest load 3,000 tons and upwards, aggregating 274,377 tons, and averaging 3,306 tons; twenty-three steamers that carried in their largest load 4,000 tons and upwards, aggregating 103,466 tons, and averaging 4,499 tons; twelve steamers that carried in their largest load 5,000 tons and upwards, aggregating 67,126 tons, and averaging 5,594 tons, and six steamers that carried in their largest load 6,000 tons and upwards, aggregating 36,428 tons, and averaging 6,071 tons. There were thirty-seven sail vessels that carried 2,000 tons and upwards, aggregating 90,597 tons, and averaging 2,449 tons; twenty-eight sail vessels that carried 3,000 tons and upwards, aggregating 100,616 tons, and averaging 3,593 tons; three sail vessels that carried 4,000 tons and upwards, aggregating 12,572 tons, and averaging 4,191 tons; sixteen sail vessels that carried 5,000 tons and upwards, aggregating 87,462 tons, and averaging 5,466 tons, and two sail vessels that carried 6,000 tons and upwards, aggregating 12,348 tons, and averaging 6,174 tons.

The greatest number of miles run during the season is to the credit of the steamer *Harlem*, of the Western Transit Co.'s fleet, Buffalo, amounting to 49,853 miles. The greatest amount of freight carried by a single vessel during the season is to the credit of the steamer *Andrew Carnegie*, of the Wilson Transit Co.'s fleet, Cleveland, and amounts to 130,956 net tons. The mile-ton record for the season is also to the credit of the *Carnegie*, and amounted to 114,571,524. The largest single cargo carried by a steamer during the season is to the credit of the *Empire City*, Zenith Transportation Co., of Duluth, and amounted to 6,171 net tons. The largest single cargo carried by a sail vessel during the season is to the credit of the tow barge *Amazon*, of the Corrigan fleet, Cleveland, and amounted to 6,244 net tons.

The United States Canal was open to navigation during the season 234 days, and the Canadian Canal, 238 days.

The amount of freight carried to and from Lake Superior during the season of 1897 was 18,982,755 net tons, which is an increase of 2,743,694 net tons, or 11 per cent., in comparison with the season of 1896. Vessels were delayed at the canal during the season 7,396 hours and 20 minutes, or an average of 34 minutes and 38 seconds.

The records show that vessels were aground on the miter sill of the movable dam for a total of 42 hours during the season.

The railway swing bridge across the canal was delayed by boats 2 hours and 13 minutes, and the boats were delayed by the bridge only 5 minutes.

The canal postoffice handled 81,872 pieces of mail, consisting of 71,208 letters, 4,276 postal cards, 6,048 newspapers and 340 parcels. In addition to the above, 605 pieces were returned to the city postoffice as "uncalled for," and 1,355 pieces were forwarded to new addresses.

NOVEL TYPE OF TOWING STEAMERS AND BARGES FOR SERVICE ON THE YUKON.

[Reprinted from "Marine Engineering" for June, 1898.]

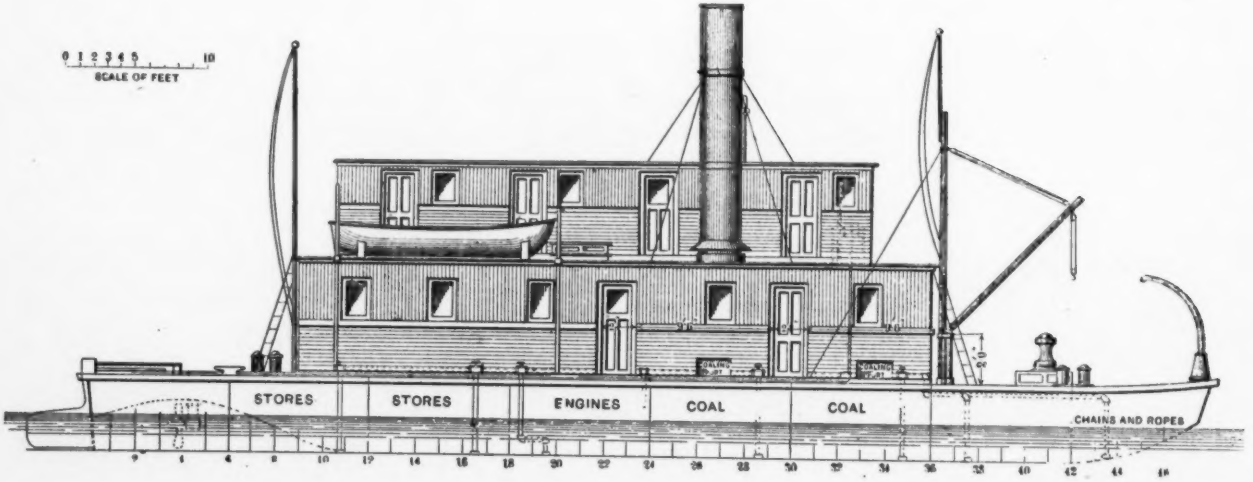
Eight new boats for the Yukon are building at the Crescent Ship Yard, Elizabethport, N. J., of which Lewis Nixon is the proprietor. They are for the Empire Transportation Co., to be run in connection with the Pacific coast line of that company, which was described at length in our March issue. The river fleet comprises two steam tugs, two passenger barges and four freight barges. The boats will operate in two fleets, each consisting of one tug, two freight barges and one passenger barge.

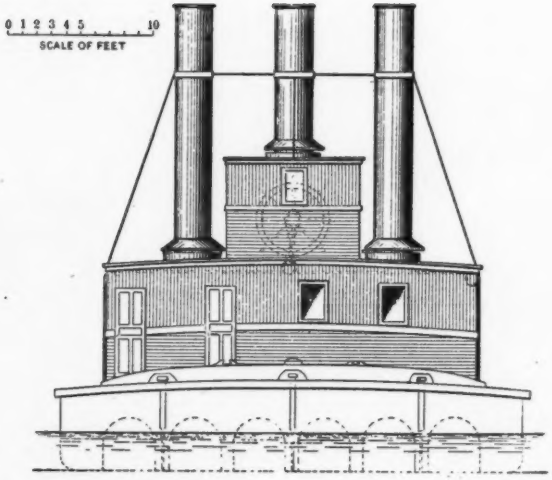
In the design of these boats full advantage has been taken of experience gained with the light-draught gunboats, *Sheikh* and *Sultan*, built in 1897 by Yarrow & Co., of London, for the Egyptian Government, on designs by Sir William White.

The general arrangement of the tugs is shown in the illustration on opposite page. Their dimensions are: Length over all, 80 feet; breadth, 32 feet; depth, 5 feet 6 inches; draught, 2 feet 6 inches.

Each tug is composed of eight separate pontoons, which will float separately, and when joined form one complete molded hull.

The construction of the two after pontoons calls for special remark. Each tug is to be propelled by six screws. For each of these an entirely independent waterway is worked in the bottom plating of the two after pontoons. The illustration of the general arrangement of the tug shows these tunnels, and they can be plainly seen in the end elevation. The frames of the two pontoons, shown in the drawing by broken lines, are worked to the exact section of the tunnels by their planes, except the frame crossing the stern tube. It is arched over the latter. The


0 1 2 3 4 5 10
SCALE OF FEET
STORES
STORES
ENGINES
COAL
COAL
CHAINS AND ROPES



END ELEVATION SHOWING TUNNELS FOR THE SIX PROPELLERS.

frames of these two pontoons, therefore, act as girders in stiffening and strengthening the propeller tunnels.

The bow pontoons are built with transom framing similar to that used in the construction of sterns in ordinary merchant practice.

The pontoons are to be tied together by $\frac{7}{8}$-inch bolts spaced 6 inches apart all around the angle irons worked on the outside edges of the bulkheads forming the forward and after ends of each pontoon, and by butt-straps bolted outside the hull just below the yellow pine deck stringers. These butt-straps are 36 inches wide, 7 feet long and $\frac{1}{4}$ inch thick. The pontoons can be put together afloat by first filling the bolt holes below the water line with wooden plugs, and then replacing them, one by one, by the bolts.

The machinery equipment of each tug will include three Roberts safety water-tube boilers of 335 H.P. each, carrying steam of 200 pounds pressure. The engines will take full boiler pressure, there being no reducing valves. The combined grate surface of the three boilers will be 100 square feet, and the heating surface about 3,000 square feet. Each tug has room for 60 tons of coal in her bunkers, and the first barge of each tow will carry 200 tons more. The tug can be coaled directly from the barge through chutes.

The ordinary water of the Yukon River cannot be used for boiler feed, being too full of clay and silt. A surface condenser will be used, but some feed make-up will, of course, be required, so fresh water will be carried in one pontoon of each tug. The streams emptying into the Yukon all along the route of these vessels are clear, so for some distance directly below their mouths the feed reserve can be replenished from the river.

To enable the boilers to burn wood as well as coal, the boiler casings are made of two layers of asbestos board with an air space between, and the bottom row of tubes is raised higher above the grates than usual.

The cylinders are of cast iron, and the piston rods, eccentrics, crank shafts and motions are of cast steel, furnished by the American Steel Co., Thurlow, Pa. The crossheads are of phos-

phor-bronze. The shaft couplings are of cast iron, shrunk on and secured by keys. Each crank shaft has on it three thrust collars abaft the cranks, and the coupling at its after end is enlarged into a jacking wheel. The engines jack by hand. In addition to the twelve engines for service, there are two complete spares. All parts of all fourteen engines are interchangeable. The engines were designed and built by Samuel L. Moore & Sons Co., Elizabethport, N. J. The order for the engines required all fourteen to be complete in sixty days, and one to be complete in thirty days. Both requirements were fulfilled.

Notwithstanding the high steam pressure used, compound engines were adopted instead of triple-expansion, partly because of lower first cost and shorter time needed for construction, but principally because of their greater simplicity and fewer working parts, and consequent fewer repairs and greater ease of making the same.

The propeller shafts have brass sleeves shrunk on and secured by set screws, to form the rubbing surfaces in the stern tube and strut bearings. According to the usual fresh-water practice the propeller shafts will have no protection outside the bearings except paint.

Each stern tube has a canted flange cast on it, which bolts to the inclined forward surface of its propeller tunnel inside. The removal of the stern-tube stuffing box gives access to the stern-tube bearing, which is made in longitudinal halves to facilitate removal. The tugs can be trimmed by the head sufficiently to allow any stern-tube bearing to be shifted while afloat.

The propeller strut bearing is also made in longitudinal halves for easy removal. The struts will be merely bolted, instead of riveted, to the roofs of the tunnels for convenience in removal.

The propellers are 40 inches in diameter, of cast iron, with the hub and blades in one piece. There are four blades of large area, the projected area being about 50 per cent. of the circle swept by the tips of the blades less the projected area of the hub. Each blade is nearly a trapezoid, with the longer of the parallel sides at the periphery. The edges of each screw tunnel are well below the water line, so that each tunnel forms an air-

tight compartment sealed by the outside water. The action of the screw gradually pumps the air out of the tunnel, and the atmospheric pressure at the same time raises the water in it, until the tunnel is finally full and the screw works in solid water, notwithstanding that under normal conditions it projects one foot above the water line. The propellers will have about the ordinary efficiency, in spite of the great friction created by the walls of the tunnel, because the centrifugal loss will be largely done away with by confining the propeller race in the tunnel. With the *Sheikh* and the *Sultan*, which were 145 feet long, and 24 feet 6 inches beam, Yarrow & Co., on a trial at a draught of 1 foot 11½ inches, obtained a speed of a trifle over thirteen miles an hour, with twin screws more than half above the water line and working on this principle.

Mr. Nixon estimates the speed of his Yukon boats as twelve miles an hour for the tug alone, and nine miles an hour for the tug and tow. The tips of the propeller blades run 2 inches above the bottom of the hull, and above the propellers are entirely enclosed by the hull, so that there is little risk of injury to them, but twenty-four spare ones are provided for the two tugs. Each tunnel has a manhole right on top, closed by a cast plate of section so arched that it forms a perfectly fair surface with the interior walls of the tunnel. When this plate is removed, the water in the tunnel falls to the level outside, and the tug while afloat can be trimmed enough by the head to allow work to be done to any screw, strut or strut bearing, even to the extent of removing it and putting in a new one.

In the *Sheikh* and the *Sultan* this system of propulsion was adopted because of the military advantages which it offered, especially in that it permitted the propelling machinery and its attendants to be more sheltered than they could be with paddle-wheel machinery. In these Yukon boats it was adopted principally in order to save weight. Their engines will run at from 200 to 225 revolutions per minute, as against about 40 revolutions with a stern wheel. By using a compound stern-wheel engine a fair economy would be obtained, but it is expected with these engines to do even better. This, combined with the great

saving of engine weight, will enable enough coal to be carried for the round trip, so that these fleets will be relieved of the necessity of tying up during the trip to coal ship. Besides, there is much greater security against break down, as the complete wrecking of an engine would disable only one-sixth of the power. This system of propulsion also offers great advantages in handling. With the *Sheikh* and the *Sultan* it was found that from full speed ahead they could be brought to rest in about two lengths. Such quickness is of the utmost value in navigating shallow rivers, the beds of which are continually changing, especially in lonely waters like the Yukon, where a vessel aground would find it difficult to get assistance.

Each tug will be provided with one centrifugal circulating pump, a Worthington independent, vertical, twin-cylinder air pump, and vertical Admiralty feed pumps. There will also be a full outfit of fire and bilge pumps, one powerful steam capstan, and two cargo derricks to each tug. Each tug will also have an electric-light plant consisting of one General Electric direct-connected lighting set, supplying current to sixty lamps and one search light. The voltage will be 110. The search lights are building by the Philadelphia Electro-Dynamic Co.

The first two barges of the tow will be for freight, and the last one for passengers. The dimensions of both freight and passenger barges are: Length, 100 feet; breadth, 35 feet; depth, 5 feet 6 inches; draught, 2 feet 6 inches; and each barge is made up of ten pontoons. The passenger barges will have fixed berths on the main deck and state rooms on the upper deck. Each fleet can carry 800 persons and 2,000 tons of freight.

The empire Transportion Co.'s steamer *Conemaugh* is now on her way around to the Yukon. She will be anchored three or four miles out at St. Michael's as a repair ship for the line. She will have complete machine and blacksmith shops capable of handling as large work as will be necessary.

One tug will be completed and put into the water here, and will have a trial trip. The machinery will then be removed, and the cabins and pontoons taken apart. The two passenger barges were shipped April 4, two more barges followed about April 18,

and the entire fleet was on the way early in May. The cabins are built in sections and assembled at the yard. The cabin sections, pontoons and machinery will be shipped by rail to Seattle and thence by steamer to St. Michael's. Sea-going vessels there must anchor at least a mile and a half out, and the system of construction adopted allows the pontoons to be simply lowered overboard, floated into place, and bolted together, without going to the great expense and loss of time taking them ashore, erecting them on ways, riveting together and launching.

The first trip on the Yukon will be made as soon as the ice gets out, probably about June 20. This will be a link in a direct line from Europe to the Klondike.

THE FIRST BATTLE BETWEEN MODERN ARMORCLADS.

The following account of the great naval victory at Santiago on Sunday, July 3, 1898, is reprinted from the "Literary Digest." It agrees, practically, with the official reports, and is in a more condensed form.

Two months after the destruction of Spain's squadron at Manila, Admiral Cervera's fleet was annihilated at Santiago de Cuba. The total American loss in the latter engagement was one man killed and two men wounded. Not a ship of the United States Navy was seriously injured. Acting Rear-Admiral Sampson's first account of the victory off Santiago was as follows:

"PLAYA, *via* HAITI.

"SECRETARY OF NAVY:

"3·15 P. M., Siboney, July 3.—The fleet under my command offers the Nation as a Fourth of July present the destruction of the whole of Cervera's fleet. No one escaped. It attempted to escape at 9·30 A. M., and at 2 P. M., the last, the *Cristobal Colon*, had run ashore 60 miles west of Santiago and has let down her colors, the *Infanta Maria Teresa*, *Oquendo* and *Vizcaya* were forced ashore, burned and blown up within 20 miles of Santiago; the *Furor* and *Pluton* were destroyed within four miles of the port. Loss one killed and two wounded. Enemy's loss probably several hundred from gun fire, explosions and drowning. About 1,300 prisoners, including Admiral Cervera. The man killed was George H. Ellis, chief yeoman of the *Brooklyn*.

"SAMPSON."

A supplemental report from Commodore Watson to the Navy Department said:

"At 9·30 A. M., the Spanish squadron, seven in all, including one gunboat, came out of Santiago in column and were totally

destroyed within an hour, except the *Cristobal Colon*, which was chased forty-five miles to westward by the Commander-in-Chief, *Brooklyn*, *Oregon* and *Texas*, surrendering to the *Brooklyn*, but was beached to prevent sinking.

"None of our officers or men were injured except on board the *Brooklyn*. Chief Yeoman Ellis was killed and one man wounded. Admiral Cervera, all commanding officers, excepting of the *Oquendo*, about seventy other officers, and sixteen hundred men are prisoners. About 350 killed or drowned and 160 wounded, the latter being cared for on the *Solace* and the *Olivette*.

"Have just arrived off Santiago on the *Marblehead* to take charge while the Commander-in-Chief is looking out for *Cristobal Colon*."

Admiral Cervera's report to Captain-General Blanco read:

"To the General-in-Chief, Havana:

"In compliance with your orders, I went out yesterday from Santiago de Cuba with all the squadron, and after an unequaled combat against forces more than triple mine, had all my squadron destroyed by fire, *Teresa*, *Oquendo* and *Vizcaya* beached and the *Colon* fleeing. I accordingly informed the Americans, and went ashore and gave myself up. The torpedo-boat destroyers foundered. I do not know how many people were lost, but will surely reach 600 dead, and many wounded. Although not in such great numbers, the living are prisoners of the Americans.

"The conduct of the crew rose to a height that won most enthusiastic plaudits of the enemy. The commander of the *Vizcaya* surrendered his vessel. His crew are very grateful for the noble generosity with which they are treated. Among the dead is Villamil, and I believe Lasaga, and among the wounded Concas and Eulate. We have lost all and are necessarily depressed.

"Cervera."

Admiral Cervera's squadron was popularly known as the Cape Verde fleet, having left the Cape Verde Islands upon Portugal's proclamation of neutrality, April 29. It comprised the best fighting ships of Spain's Navy, and until its destination on this

side of the Atlantic became known, plans for the conduct of hostilities on the part of the United States were in a state of uncertainty. The fleet was first sighted off Martinique, West Indies, then at Curaçoa, off the coast of Venezuela, and at length definitely located in the harbor of Santiago de Cuba. Acting under orders to seek and destroy the Spanish fleet, Acting Rear-Admiral Wm. T. Sampson assembled a large fleet to command the entrance to the harbor, gave Naval Constructor Hobson permission to sink the *Merrimac* in order to block the harbor, bombarded coast fortifications, and co-operated in the transfer and landing of troops for the siege of the city of Santiago. Constant vigil off the harbor was maintained, so that when Admiral Cervera, acting under orders, took chances of escape while Admiral Sampson was engaged in operations at Aguadores, he was quickly discovered and promptly attacked.

Admiral Cervera's fleet at Santiago consisted of four armored cruisers, the *Vizcaya*, *Oquendo*, *Cristobal Colon* and *Maria Teresa* (flagship), and two torpedo-boat destroyers, the *Pluton* and *Furor*. They were all modern ships. The cruisers had 12-inch steel armor, speed of 20.2 knots, and a total armament of 160 guns (two 11-inch Hontoria breech-loaders on each ship), and about 30 torpedo tubes. They carried a complement of 1,952 officers and men. The torpedo-boat destroyers were of English build, the latest type of steel construction, with armament of six guns—the heaviest being 14-pounders, quick-fire—and two torpedo tubes each. The two destroyers carried 140 officers and men.

These ships on leaving the harbor at full speed, were engaged by five United States battle ships, the *Texas*, *Oregon*, *Iowa* and *Indiana*, the armored cruiser *Brooklyn* (Commodore Schley's flagship), and the converted steel pleasure yacht *Corsair*, renamed the *Gloucester*. The speed of the *Texas* is 17 knots; the *Oregon's*, 16; the *Iowa's*, 16; the *Indiana's*, 15.54; the *Brooklyn's*, 22. The total armament of the five ships is 198 guns (including eight 13-inch and six 12-inch guns), and 27 torpedo tubes. The "World" almanac's figures give them a complement of 2,236 officers and men. The *Gloucester* carried six-pounder guns and was in command of Lieutenant-Commander Richard Wainwright, formerly

the executive officer of the battle-ship *Maine*. Admiral Sampson's flagship, the *New York*, in response to a message by dispatch boat, arrived on the scene of action near the close of the battle and fired several shots; it cannot be fairly reckoned in the above comparative estimate of the opposing fleets. Commodore Schley was in virtual command during the engagement which resulted in the destruction of the Spanish fleet, while the newspaper accounts indicate that it was essentially a pursuit by individual ships. The *Oregon* succeeded in getting in shots on every one of the enemy's ships, and passed the rest of the fleet to join the *Brooklyn* in the finish.

From the graphic account of the battle sent to the New York "Journal" and New York "Sun" by a correspondent on board the battle-ship *Texas*, which lay directly in front of the harbor, and was said to have first signalled, "The enemy is trying to escape," we quote at some length:

"Hardly was the leading Spanish ship clear of the shadows of old Morro before boom went one of her big guns—and the battle had begun. That first shell went wild. . . .

"The Spaniards turned to the westward, and we kept boring in on them. They fired incessantly, and kept their engines going under forced draft, evidently intending to outrun us and escape. The *Brooklyn*, just as good at the running game as they were, turned her course nearly parallel with theirs, though drawing into closer quarters a little all the while. . . .

"We were in close enough now, so we turned west with our adversary. Our speed was not equal to hers, but what we lacked in speed we made up with shells. We could see that our shots were getting home, but the enemy replied with much spirit and some accuracy.

"Captain Philip was on the bridge up to this time, but it soon became the part of discretion to retire, so he ordered the bridge contingent to the conning tower passage, taking control of the ship from the tower itself.

"There is a good angel presiding over Captain Philip. Hardly had he left the bridge when a big shell from one of the fleeing Spaniards ripped right through the pilot house. It cer-

tainly would have killed the man at the wheel and possibly every officer on the bridge had not the captain given his conning tower order just as he did. . . .

"For half an hour the enemy's shells whistled all about the *Texas*. One more got home. This one bored a hole through the ash-hoist amidships and exploded inside the smokestack, doing some merely incidental damage and injuring nobody.

"Our own guns, however, were enough to kill delicate men. Their din was so dreadful that orders had to be shouted right into the ears of our messengers. Then the smoke would come up in such density that we couldn't see each other.

"On two occasions the 12-inch turret guns were swung athwart ship and turned loose. The concussion then shook the immense vessel as if she had been a toy boat. The sensation was much as if we had been struck with a big projectile. Everything movable was splintered. All the men near the guns were thrown on their faces. Seaman Schram was knocked through a hatchway into the forward handling room, breaking his leg.

"But the enemy must have suffered more then we did from the shots, for we held a deadly range, and the guns were being served as guns never were served before.

"The *Oregon* had come whirling past, and went on to help Schley and the *Brooklyn* dispose of the leading Spanish ships. The *Iowa*, too, had turned westward, and was continually thundering. We were all in the mess up to our elbows.

"She's on fire!

"That was the word we passed from ear to ear, skrieking it in our joy, for masses of smoke were pouring from our particular antagonist, and in a pause of the firing we heard our men cheer and shout their glee. Our big shells had got through her armor, and we felt that our part of that fight was nearly won.

"Soon we saw that our smoking and battered adversary was done for and was making at all speed for the beach. So we let her go and began firing at the cruiser steaming behind her—the fourth in the Spanish line. . . . The *Brooklyn* and *Oregon*, after a few parting shots, also abandoned all effort to help us smash this particular cruiser, and devoted all their steam and

guns to the two foremost vessels, which we took to be the *Oquendo* and the *Cristobal Colon*. . . .

"Gun for gun, shot for shot, the four big American vessels and the four finest ships in Spain's navy kept up the fight. By 10·30 o'clock—one hour from the time Lieutenant Bristol saw that cloud of smoke—the two cruisers, which were last to leave the harbor, were smoking ruins, going on the beach to keep from sinking.

"Up went a white flag on the one nearest us, and 'Cease firing!' was Captain Philip's immediate order. A moment later both Spanish cruisers were beached, and bright flashes of flame coming through the smoke which enveloped them told of the destructive force of boiler or magazine explosions.

"We could see the ships' boats, crowded to their gunwales, pulling for the shore. The *Iowa*, which had received some pretty hard knocks in the fight, remained to see that these two ships were really done for, while the *Brooklyn*, *Texas* and *Oregon* pushed on to end or capture the other two, which were racing for life along the coast to the westward, well in shore.

"At 10·50 o'clock Cervera's flagship, the *Oquendo*, suddenly turned for the shore, the *Oregon* and *Brooklyn* pounding her abeam, while we were blazing away astern.

"On went the *Brooklyn* and *Oregon* after the *Cristobal Colon*, which really looked as if she were going to get away, as she was making great speed. We were left to give the *Oquendo* the *coup de grâce*.

"It didn't take us long. The Spanish Admiral's ship was already burning, and at 11·05 down came the yellow and red flag at her stern, and we swung in abeam.

"Then, in a moment, there was a mighty explosion on the *Oquendo*, and our boys set up a cheer.

"'Don't cheer boys!' shouted Captain Philip. 'Those poor devils are dying!'

"So we left her to her fate to go plugging on after the *Colon*, which, in her desperation, was plowing through the water at a pace that put the *Brooklyn* to her best efforts. The *Oregon* was making wonderful speed for a battle ship, and we just settled

down to make the effort of our lives. Never since our trial trip have we done so well.

"We all feared that the *Cristobal Colon* would leave us all except the *Brooklyn*, and Commodore Schley's ship was not supposed to be a fair fighting match for the big Spanish cruiser. We couldn't afford to have it said that even one of the Spanish ships got away, so these moments of the chase were thrilling ones.

"Straight into the west we headed, blazing and banging as we went, in the greatest marine race of modern times. The *Brooklyn* headed out toward a point, in the endeavor to cut off the Spaniard there, while the *Oregon* held to a middle course, not much over a mile from the cruiser, and we hammered away from the *Colon's* wake.

"The desperate don hugged the shore, firing now and again at us and giving the *Brooklyn* and *Oregon* her best fire. We held up astonishingly well under our forced draft, and no one need ever sneer at the speed of the old *Texas* again.

"But, run as she might, the Spaniard had no chance. The *Brooklyn* gradually forged ahead of her and got between her and the place where she would have to make her swing to round that point. For over two hours she had led us a lively chase, but her time had come. The *Oregon* held her abeam, and the *Texas* astern. There was no way of escape.

"At 1·15 in the afternoon the gallant *Colon* gave it up and turned her bow for the beach. At 1·20 down came her flag, although not one of our ships was then within a mile of her, but we all closed in, *Brooklyn*, *Oregon* and *Texas* together, stopping our engines a few hundred yards away.

"Then up steamed the *Resolute* to take off the *Colon's* prisoners. There were 530 of these prisoners, and eight men were missing.

"We had hoped to save the *Colon* as a Fourth of July offering to the American people and the American Navy. Beached bow on with a sandy shore and her stern afloat, she did not seem greatly damaged by shots. One 13-inch shell and one 8-inch had hit her full and fair, but the damage was not sufficient to cause her to sink.

"The Spaniards balked us, however. After they had found themselves safe, they had opened every sea-valve and every port, throwing the valves overboard and smashing the deadlights. They had even thrown away the breech-plugs of their guns."

The New York "Herald" described the *Gloucester's* exploit thus:

"Lieutenant-Commander Richard Wainwright, in command of the *Gloucester*, paid no attention to the guns of Morro. He was second in command of the *Maine* when she was blown up in Havana harbor, and he was the last to leave the wreck, after having toiled over her, day after day, recovering the mangled bodies of the American sailors. His remembrance of the *Maine* was too vivid to allow him to wait.

"When the two destroyers emerged from the channel leading to the harbor, Lieutenant Wainwright opened fire upon them alone with his six-pounders.

"Both the destroyers and the *Vizcaya* opened on the plucky little yacht. In spite of all she could do, the destroyers passed her and left her astern.

"Lieutenant Wainwright soon got another chance, however. When the destroyers encountered the deadly rain of missiles from the battle ships beyond, their commanders quickly came to the conclusion that discretion was the better part of valor, and turned back, in the hope of saving themselves in the harbor.

"They reckoned without the *Gloucester*. She was waiting for them and renewed the engagement as soon as they came within range of her small guns. They replied as before, and the *Gloucester*, as before, sustained their fire without flinching.

"This duel between two of Spain's most dreaded craft on one side and the converted American yacht on the other was the most thrilling feature of the entire engagement. The *Gloucester* was apparently damaged by the shot poured into her by the destroyers, but, with marvelous bravery, she gave them shot for shot, doggedly determined to prevent their escape.

"The courage of her commander in the face of such tremendous odds was finally rewarded. The terrible fire of the de-

stroyers slackened, and a cheer went up from the *Gloucester*, as it was seen that they were on fire.

"Both turned their noses to the shore and crowded on steam. They had need of haste, for one of them blew up as her crew was plunging into the surf. The other was beached and her men scrambled ashore.

"Admiral Sampson, with the flagship, returned in time to send two shots at the destroyers, but it was the *Gloucester* that cut off their retreat and defeated them in a fair fight. Both the destroyers were burned on the beach."

MANUFACTURE OF ALUMINUM.

Aluminum Manufacture, with Description of the Rolling Mills and Foundry at Milton, Staffordshire.*

By Mr. E. Ristori, of London.

On the occasion of the meeting of the Institution of Mechanical Engineers at Belfast in July, 1896, Mr. James Sutherland, the manager of the factory at Larne, read a paper which fully described the method adopted for the preparation of pure alumina (oxide of aluminum), from bauxite. Members who then visited that factory will be interested to learn that the British Aluminum Company have already been compelled to enlarge the works to nearly double the capacity, and that great improvements have since been introduced into the process of manufacture. The finished product is a very finely divided powder; and in order to ship it safely to Foyers, it has been found advisable to pack the alumina in hermetically sealed steel drums. On arrival in Scotland, the oxide is reduced by the Héroult process, and the metal is run out of the electrolytic baths into ingot moulds. In this form the aluminum is quite pure enough for certain purposes, such as foundry work and steelmaking; and much of it is therefore sold without further treatment. But as small quantities of the cryolite—a double fluoride of aluminum and sodium containing 13 per cent. of aluminum—which is used as a solvent during the electrolysis, occasionally become mixed with the metal as it comes out of the furnace, the aluminum at this stage is scarcely suitable for the production of tubes, rods, etc. The original crude ingots are therefore sent to Milton, in Staffordshire, where they are remelted and refined until the metal attains a purity of 99.6 per cent.

* Paper read before the Institution of Mechanical Engineers.

Milton Works.—The site of the Milton Works, which the members will have an opportunity of visiting, is well selected, in the middle of an industrial district; it is connected with the North Staffordshire Railway by a siding, and has a frontage on the Trent and Mersey Canal. They were the first works erected in the United Kingdom for the production of aluminum by electrical agency. They were erected by the Cowles Syndicate for the purpose of turning out aluminum and aluminum-bronze by the well-known "Cowles" process; but before the British Aluminum Company took them over they had already stopped making aluminum, having been previously driven out of the field by the competition of the electrolytic methods, which were greatly assisted by the employment of cheap water power. It was found useful, however, to convert this factory into a rolling mill and foundry, with the idea not only of refining the Foyers ingots, but also of working them up into sheets, rods and large or small castings, more convenient for the different trades that use aluminum. A portion of these works, which was not required for the above purpose, was sublet to the Epstein Electric Accumulator Company, who have been making and charging their accumulators here for the last three years; this portion includes two tubular boilers and one engine of 650 indicated horse power.

Casting Shop.—The casting shop, erected in 1895, is situated close to the rolling mills, and contains a series of eleven furnaces for 500-pound pots, connected by a large flue to the main chimney, 125 feet high, which gives a good draft for melting large quantities of bronze in a short time. This shop can deal with about forty tons of aluminum per day, in the shape of ordinary commercial notched bar, half-round stick for steelmakers, slabs for rolling, tube billets for drawing, wire billets, both round and shaped for various purposes. When casting the metal, it is sometimes necessary to add a little cryolite or some similar flux for assisting in the liberation of the impurities, which then rise to the surface as scum. These refining furnaces are fired with soft coke, because aluminum does not require such a high temperature as is necessary for bronze. The scum taken from the top

of the pots is again remelted very slowly, in order to recover all the aluminum; it then forms a whitish powder, containing practically nothing but the cryolite and some carbon, and being quite suitable for use in the Héroult reducing cell, is sent back to Foyers for further employment. An overhead traveling crane is used for lifting the ingot molds and pots. Experiments have been made in casting slabs and billets with a side runner, which seems to offer certain advantages.

Foundry.—The principal building, which was originally intended by the Cowles Syndicate to be an engine and dynamo house with outside boilers, is 200 feet long by 65 feet wide and 20 feet high under the principals. A portion of this is now used as a foundry, and contains two large core ovens, each 16 feet by 23 feet, having a door 14 feet by 10 feet high, fired with coke fires under the floor; a cupola; two series of crucible furnaces to hold 500-pound pots, and two traveling cranes, sufficient to handle weights up to fifteen tons, which, so far, have been sufficient for all the foundry work up to bronze castings of five tons weight, and aluminum castings of two tons. A considerable extension of the plant is contemplated.

In making bronze castings, the metal is not poured straight into the mold in the usual way of casting iron, but into a runner box, or, for a large casting, into a number of runner boxes, having holes in the bottom corresponding with the gates of the casting. During the time the metal is being poured into the runner box, these holes are filled with iron plugs until all the metal is in the runner box; the plugs are then taken from the holes, so that the metal runs into the gates of the casting from the bottom of the runner box, and leaves the scum behind in the box, or in the top of the gates. In making castings of aluminum, it is not sufficient to use runners of the same size as those usually employed in making brass and iron castings. As the shrinkage of aluminum is about three times the shrinkage of ordinary gun-metal, a considerable amount of trouble is experienced if the runners and risers are not large enough to allow the casting to continue to be fed during its shrinking.

Rolling Shop.—The rolling shop measures 130 feet by 60 feet,

and is covered with a weaving-shed roof having a north light. At present it contains two pairs of rolls 18 inches in diameter by 42 inches in width; one pair 18 inches in diameter by 48 inches in width; one pair 18 inches in diameter by 20 inches in width; one pair 14 inches in diameter by 20 inches in width; one pair 14 inches in diameter by 30 inches in width; and a new pair of friction rolls 22 inches in diameter and 60 inches wide is in process of erection. All are driven by gearing from a horizontal, tandem, compound-condensing engine, put up in 1896. This engine runs at 60 revolutions per minute, and has cylinders of 21 inches and 40 inches in diameter and 40 inches stroke, and is capable of driving still more machinery. The steam is supplied by a Lancashire boiler, 8½ feet in diameter and 30 feet long, placed at the side of the house. The driving gear consists of helical tooth wheels, 12 inches wide and from 6 feet to 9 feet in diameter, driving the rolls at about 10 revolutions per minute. The 14-inch rolls are both fitted with a friction wind by Messrs. Jones, of Birmingham, with which strips as fine as 0.0005 inch have been successfully rolled to a length of from 60 feet to 90 feet.

The rest of the plant required in a rolling mill is also contained in this building. It includes a guillotine shearing machine for ½-inch plates, 8½ feet wide; a crocodile machine for plates up to 1 inch thick; two circular cutters, one for the manufacture of disc blanks 9 inches to 24 inches in diameter up to 14 S.W.G., or 0.085 inch thick, the second, up to 4 feet in diameter and ⅜ inch thick, which are sold for stamping purposes; a steam hammer, for closing the grain and for strengthening alloys before they are rolled into sheets, is in an adjacent building. A press is also being prepared for punching discs up to 12 inches in diameter. Two annealing furnaces, or muffles, are also provided, 5 feet by 12 feet, and 7½ feet by 14 feet; these are a most important item in the plant for either rolling or hammering metal. Slabs 24 inches wide by 1¼ inches thick are broken down hot, after being heated in the muffle; they are afterwards again heated when necessary between the successive passes to reduce them from 1¼ inches thick to ¼ inch. Most of the rolling itself is done

cold; and in some cases, especially when very pure aluminum is used, even the breaking down can be done cold. Connected with the rolling mill is a pickling shop, containing tanks 12 feet by 3 feet, charged with caustic soda, water, nitric acid, sulphuric acid, &c.; the pickling process has to be carried out whenever a good polish is required on the finished sheets, while it is also equally adapted when a mat surface is desired.

Fitting Shop, Testing Machine and Laboratory.—The fitting shop is subdivided into several buildings, and is provided with a quantity of ordinary lathes, circular and band saws, a nicking machine, shaping machine, and a number of small presses for cutting blanks out of sheet metal. In another building next to the rolling mill there is a cold saw to cut metal 20 inches thick, especially used for cutting heads off aluminum-bronze castings which cannot be handled or cut up in any other way. If the bronze is made hot, it can be forged into any shape. Most of it has a tensile breaking strength of 30 to 35 tons per square inch, and it is useless trying to handle the heads in any other way than by sawing.

The Milton factory contains also a 30-ton Wicksteed testing machine, in which the different bronzes and light aluminum alloys are constantly being tested. There is also a chemical laboratory, in which the sample tappings from the furnaces at Foyers are analyzed and records preserved, so that the purity of any particular delivery can always be ascertained. The whole works are lighted electrically from two dynamos; and a motor is kept ready for occasional assistance in driving the machinery.

Working of Aluminum.—With certain limitations, imposed by the chemical and physical peculiarities of the material, aluminum can be worked much like the other industrial metals handled at the present day. It is best melted in sand or in iron crucibles without the addition of any flux, at a temperature not greatly exceeding its melting point, 655 degrees cent. = 1,210 degrees Fahr. On a larger scale, the operation can be carried out at a dark red heat on the bed of a reverberatory furnace lined with basic magnesia bricks of good quality. In casting, special precautions must be taken to allow for the great shrinkage during

cooling. The molds should have large risers and plenty of vents. They are preferably cooled from the bottom upwards to enable the gases to escape. Slabs for rolling must be cast in closed ingot molds with a perfect machined internal surface, which is coated all over with graphite and water; the molds must be very hot, and the castings cooled quickly in very cold water to make them soft.

Aluminum can be forged hot or cold; preferably at a temperature which causes a hard wooden stick to smoke when pressed against the metal. In comparison with other metals it ranks third in order for malleability and sixth for ductility; sheets have been hammered as thin as $\frac{1}{40000}$ inch, and wire can be drawn down $\frac{1}{250}$ inch in diameter. No lubricant should be used for rolling; and the aluminum requires frequent annealing at a low red heat just visible in the dark. In turning, the edge of the tool soon becomes blunt, unless only small cuts are taken; the cutting speed should be high, and both tool and metal should be lubricated with turpentine or petroleum. Filing is best done with single-cut files, because cross-cut files rapidly become choked. Spinning is easy on wooden or metal forms, the best lubricant being stearic acid dissolved in turpentine. Aluminum can be stamped or pressed, hot or cold, either dry or with soap water for heavy work, and with tallow for small goods. Frosting is effected by dipping the articles for a few seconds in a hot 10 per cent. solution of caustic soda containing about $2\frac{1}{2}$ per cent. of common salt till the surface turns black, then brushing in cold water, and dipping in strong nitric acid till the metal becomes white again, and finally washing and drying in sawdust. This process is desirable before aluminum surfaces can be efficiently painted or enameled. For polishing, a mixture of olive oil and rum is used, or emery and tallow, followed by rouge and turpentine. Burnishing is done with bloodstone or steel dipped in rum and oil, or in a solution of borax containing a little ammonia. To engrave aluminum, the plate must be coated with stearic acid and turpentine, or with rum and oil as before; if this be not done, the graver slips continually.

Alloys of Aluminum.—Among binary alloys, especially, it has

been found that, as the proportion of the two ingredients becomes more and more equal, the products lose their valuable qualities, and that the industrial alloys may be broadly separated into two kinds, namely, "light" alloys containing 90 to 99 per cent. of aluminum with 10 to 1 per cent. or even less of some other metal or metals, and "heavy" alloys containing 1 to 10 per cent. of aluminum with 99 to 90 per cent. of the other components. They can, therefore, be regarded either as pure aluminum strengthened by the addition of some other metal, or as one of the older metals improved physically and chemically by the addition of aluminum. A considerable amount of attention has consequently been devoted at Milton to the preparation of different sorts of alloys, some of which may be briefly referred to.

Light Alloys of Aluminum.—In its purest form aluminum is very soft, and not of great service in those arts in which much rigidity and strength are required. For this reason a metal containing only 98.5 to 98.8 per cent. of aluminum, the impurities being silica and iron in almost equal proportions, is preferred to metal of 99.6 per cent. purity.

One casting alloy, having a specific gravity of 2.9, is largely used just now and is known as "No. 6." Its composition is still kept secret. It has been found to produce remarkably clean castings, which require very little machining to finish up, it takes a high polish, and so far has given complete satisfaction. Another alloy is "No. 4," which contains nothing but aluminum and a small proportion of copper; it is not one of the materials generally recommended, though it has some good qualities. There is a strong suspicion that when aluminum is alloyed with copper galvanic action is set up between the two, especially when the alloy is exposed to salt water; therefore this is not recommended in any quantity for outside positions. The two alloys particularly recommended, as among the best yet made, are called "Wolframinium" and "Romanium." These are both ternary alloys, and, next to the aluminum, tungsten is the leading ingredient in each. In one of them copper is present to a small extent, in the other nickel; and both have given astonishing results as regards strength and elongation. Samples of rolled sheet or

rods made of these alloys have shown as much as 20 to 22 tons tensile strength per square inch with 5 to 10 per cent. elongation in 4 inches, which is remarkable when the low specific gravity of the material is taken into consideration. The above are all so-called "light" alloys, that is, alloys containing a preponderating percentage of aluminum with only a small quantity of another metal or metals.

Heavy Alloys of Aluminum.—There are many "heavy" alloys of aluminum, in addition to the well-known bronzes. Some of these have not yet reached the development to which their valuable qualities entitle them, and which they will ultimately attain when better appreciated by mechanical engineers. Aluminum-bronzes are undoubtedly superior in strength to most of the copper-tin bronzes now in use, and they are especially suitable for marine engineering. Propellers of aluminum-bronze have been successfully made for most of the 26 and 30-knot torpedo catchers; also a large number for the French Government. The two classes of bronze most frequently employed are marked R 3 and R 4; the difference between them is simply in the proportion of aluminum they contain. The following tests show their maximum, minimun and mean breaking loads and elongations:

Mark.	Breaking load. Tons per square inch.			Elongation. Per cent. in two inches.		
	Max.	Min.	Mean.	Max.	Min.	Mean.
R 3.....	43.7	39.6	41.8	13.00	6.50	9.75
R 4.....	36.6	30.8	34.0	35.00	15.50	23.30

Agreeably with which R 4 has a guaranteed tensile strength of 35 tons per square inch, with 25 per cent. elongation in 2 inches; and when cast R 3 breaks at 40 tons per square inch, with 10 to 12 per cent. elongation also in 2 inches. They have the advantage of being considerably cheaper than other bronzes, and are easily employed for any foundry work without special appliances or tools.

Uses of Aluminum.—The principal uses of aluminum are too many to be enumerated. The properties of the metal are so akin to those of copper and brass that, broadly speaking, aluminum, or one of its light alloys, should to a large extent replace both copper and tin, and also nickel or German silver. Such a change would be followed by various advantages to all concerned. Not only would there be a considerable reduction in the weight of the articles, but they would not tarnish or turn black on exposure to air. The cost should be the same, if not actually lower, inasmuch as, bulk for bulk, aluminum is already cheaper than copper or tin; and its price will continue to fall as the demand increases. One field, however, remains, which copper is bound to maintain as its own, namely, the construction of insulated electrical conductors. Experiments have already been made on a large scale with bare conductors of aluminum for telephones, etc.; and the British Aluminum Company are using it in this manner at their Foyers works with perfectly satisfactory results, its conductivity, weight for weight, being double that of copper. But when the mains have to be insulated, copper is absolutely unapproachable, on account of its greater conductivity volume for volume, which is 165 per cent. of that of aluminum. Besides the advantages set forth above, aluminum is not poisonous, and is pre-eminently adapted for the manufacture of cooking utensils. On the other hand, tin ware is not particulary cheap in the long run, for it is constantly wearing out; cast-iron is heavy and brittle; and copper requires to be frequently re-tinned in order to avoid all danger to health. Inasmuch as an aluminum saucepan costs no more in the first instance than a copper one, weighs much less, is perfectly innocuous, and does not periodically need a fresh inside, it is not surprising that the employment of aluminum in kitchens and canteens is spreading rapidly.

A steady demand for aluminum is springing up in various kinds of printing processes, as well as in lithography. The metal appears to answer admirably for the construction of rollers used in calico printing; and when its surface is properly prepared, it is also capable of replacing the ordinary lithographic stone. It

can easily be imagined that, instead of having cumbrous and heavy stones, which can be printed only on special slow-running "litho" machines, it is far better and cheaper to use thin sheets of a metal which can be bent into a circular form and printed on rotary presses.

Bicycles of all kinds, electric-light fittings, chains, bridles, stirrups, surgical instruments, sextants and other scientific apparatus, keys, cigar cases, pen and pencil holders, toilet articles, plates and dishes, spoons, forks, frames, name-plates, door furniture, hat and coat pegs, boot trees, fire-engine fittings, business and visiting cards, photographic cameras, &c., are a few of the things that are being daily made in aluminum by various firms; and all these articles should be sold at the same price as if they were composed of brass.

There are other instances where aluminum should economically replace commoner metals than copper or brass. Wherever a great deal of deadweight has to be continually moved about, the cost of motive power, for which there is apparently no return, is serious; and if this unremunerative weight can be reduced to one-third its present amount, in the course of a year or two the saving in power will more than compensate for the greater initial outlay. Thus frames for cabs and motor cars have already been made in aluminum; and though in England experiments have not yet been tried in this direction, aluminum railway carriage frames are under review in France. Especially for motor cars, there should be a large field here for aluminum. A further demand for the metal will be brought about by its introduction into the military services. All parts of the soldier's equipment have practically been made already in aluminum, such as mess tins, water bottles, buttons, helmets, parts of rifles, cartridge cases, fittings for guns, tents, horse-shoes, portable bridges, &c. Nothing much has yet been done in England in this direction, but it is well known that Continental armies, notably that of Germany, are employing aluminum on a large scale.

One of the largest uses to which aluminum has been applied is in metallurgy, where its valuable metallurgical properties were discovered and utilized. It is common knowledge among steel-

makers that ingots often turn out spongy at the top, and when particularly good ingots are required, the faulty portion is cut off and melted over again. By the introduction of a very small proportion of aluminum to iron, steel or brass, either in the mold or in the ladle, the founder can be quite certain that the ingots will be solid all through. When used in this way, aluminum has the peculiar virtue of instantly liberating all the gases contained in the metal, and of keeping it fluid for a longer period, so that by the time the casting solidifies, the gases have had an opportunity to escape. In almost all steel works, and in all the principal foundries, aluminum is now being employed, and reports from some of these state that the result is a reduction in the wasters by 80 or 90 per cent. In this case aluminum does not actually replace any other metal, but by its own special qualities is useful as a means of improving, physically and chemically, some of its older rivals and friends.

Aluminum in Shipbuilding.—The use of aluminum in shipbuilding is growing rapidly on account of the almost inestimable advantage of its great saving in weight. Four or five years ago a small canoe was made on the Thames of two sheets of aluminum stamped and riveted together. In 1892, Messrs. Escher Wyss, of Zurich, constructed a small launch entirely of aluminum, driven by a naphtha motor, and in the following year they built for Mr. Nobel another larger vessel,* which has been in use ever since, and is now on one of the Swedish lakes. During 1894 and 1895, the author had on the Thames, between Windsor and Maidenhead, a similar vessel, which is now at work at Foyers. A much more ambitious attempt was made by Messrs. Yarrow in 1894. By request of the French Government, they built of aluminum, the whole of a second-class torpedo boat,† 60 feet long by 9 feet 3 inches beam. This boat weighed in full working order, but exclusive of armament, only 9½ tons, and attained, during a run of two hours, carrying a load of 3 tons, and with engines indicating about 300 horse-power, a mean speed of 20½ knots—an advance of 3½ knots over all previous records. Sev-

* See "Engineering," Vol. LIV, pages 318, 319 and 326.

† *Idem.*, Vol. LVIII, page 458.

eral yachts, including the *Vendenesse*, were also constructed at the same time, but they do not seem to have been a real and permanent success, owing, probably, to the adoption of an unsuitable metal.

As pure aluminum was not strong enough alone, it was thought better to use an alloy containing about 6 per cent. of copper in the construction of some of these boats. This alloy possesses a tensile strength of 14 tons per square inch; but, as already stated, this material is absolutely untrustworthy in sea water, owing to the rapid corrosive actions set up between its two ingredients. Moreover, although nobody would dream of employing any other metal than copper for plating sea-going vessels unless it were afterwards painted, aluminum has always been used bare, which the author considers a mistake. If the aluminum had been protected from direct contact with the water, it would have lasted much better. Unfortunately, this comparative failure has materially discouraged the adoption of aluminum in shipbuilding; and although it is now well recognized that the pure metal, and several of its alloys which do not contain copper, stand the action of salt water better than iron or steel, some time is likely to elapse before these premature tests are forgotten. Eventually, however, when further experiments have been carried out, there is no reason why a suitable alloy should not be adopted, which, when properly used and protected from direct contact with sea water, would resist corrosion as effectually as the majority of materials now employed in shipbuilding. These remarks refer only to the keel and other parts of the vessel below water, and chiefly to such craft as are to navigate the open seas.

For all internal work aluminum is perfectly safe; and it is specially suitable for adoption in the Navy, where the presence of wood and other inflammable material should be discouraged as much as possible, lest it lead to fires during action. In all boats sailing on fresh or inland waters the corrosion is less; and when portability is desired, as in the case of expeditions to little-known parts of the world, even if the aluminum do suffer corrosion, this is of trifling moment in comparison with the advantage

of smaller weight to be transported. For instance, Messrs. David White, of Glasgow, have recently constructed an 18-foot boat for a party going to Klondyke, weighing only $1\frac{3}{4}$ cwt., which is wholly composed of aluminum, even to the rivets, nails, bolts and nuts. It is made in sections which pack into one another; and the whole can be put into a box. Messrs. Forrestt and Son, of Wivenhoe, have also furnished a flotilla of two launches and a barge, for Major Gibbons' Trans-African expedition which started in May. The vessels are built in sections, on the Hodgetts principle, each piece measuring about 6 feet 6 inches by 3 feet 9 inches and weighing less than 120 pounds, so that two natives can easily carry one between them by means of oars on their shoulders. The chief peculiarity of these boats lies in the interchangeability of the 20 sections composing the fleet. The different pieces can be put together in a variety of ways, forming three separate boats of such sizes as may be most convenient at the moment. It is possible to have either two 26-foot launches and one $22\frac{1}{2}$-foot barge; or one $44\frac{1}{2}$-foot launch and two 15-foot barges; or one 37-foot launch, one $22\frac{1}{2}$-foot barge, and one 15-foot barge, etc. One launch is fitted with an awning, the other carries a mast and sail.

NOTES.

THE CARE OF STEAM BOILERS.

[Reprinted from "Engineering."]

An interesting memorandum presented to the members of the Manchester Steam Users' Association has just been issued by Mr. C. E. Stromeyer, the chief engineer. It touches, in the first instance, on the life and work of the late Mr. Lavington Fletcher, to whom it pays a well-deserved tribute, not only for the success which the Association achieved under his able guidance during the long term of thirty-six years, but also for the untiring zeal with which he devoted himself to the perfecting of steam boilers, and to the combating of the erroneous views, formerly so widely held, and which still prevail in some quarters, as to the causes of explosions. For the services thus rendered, Mr. Stromeyer says, steam users and the engineering profession owe Mr. Fletcher their deepest thanks. By careful attention to the organization of a system of reliable boiler inspection the Association now stands at the head of the various organizations which have since been established in different parts of the world, having for their object the prevention of explosions, the number of which, in our own country, has been so considerably reduced in recent years.

Some original and striking figures are given as to the cost of explosions, taking as a basis the number of what are termed "proper" boiler explosions (*i. e.*, from steam boilers only) during a term of five years. The average cost of an explosion is estimated at £384; and reckoning seventeen explosions as occurring among 120,000 boilers in the United Kingdom which are uninspected by the Association or the various insurance companies, the average cost of explosions, it is stated, amounts only to about 13d. per boiler. If a boiler is thoroughly inspected and guaranteed there is practically no risk, and only two persons have ever

been injured by troubles connected with boilers under the Association's care. In these cases the injuries were slight, and the total compensation which might have been due to them under the new Workman's Compensation Act would not, it is said, have amounted to more than £25. This is out of a total of 130,000 boiler inspections; and the moral which it is intended steam users should learn from these figures is, that a system of careful inspection ought to considerably reduce the cost of insurance under this Act.

A copy is given of the "Advice to Boiler Attendants," which the Association recently published. Many of the hints and instructions are extremely useful, and form a serviceable adjunct to a boiler house. Many boilers suffer severely from scale, and on this point the memorandum makes the following remarks:

"In 1892, M. Schmidt, Engineer of the Association of Steam Users of the Somme, Aisne and Oise, read a paper before the Sixteenth Congress of Chief Engineers on a new method of cleaning boilers which had been rediscovered and adopted by one of his steam users, and which is as follows: The boiler is cooled down without running out its water. After a few days, when the temperature has fallen sufficiently to allow a man to enter, the top manhole door is removed, the water is lowered to about 1 foot below the furnace crown, and the boiler cleaners enter the boiler armed with brushes, scrapers and, if necessary, with a high-pressure water hose. They find the scale to be soft, almost muddy, and can remove it with the greatest ease. When they have cleaned the upper part of the boiler, the water is lowered 1 foot at a time as the cleaning progresses. By this means all new scale can be removed in a few hours. Should the work of cleaning the boiler not be commenced until one hour after the water has been run out, then the scale will already have become hard, and can only be detached from the plates by the tedious process of chipping. If the water is blown out under pressure the scale, being left in a dry and hot condition, is doubly hard and adhesive. Old scale, which has been in the boiler for years, does not soften again, but after a time it also yields to this treatment. On the other hand, boilers which do

not readily scale can be partially protected against corrosion by emptying them while they are still warm, when the undisturbed thin scale will harden on the warm surfaces. Inquiries made amongst our inspectors revealed that this method of cleaning had, years ago, been adopted by some steam users, and also that it was perfectly true that boiler scale is soft as long as it has not been exposed to the air, and in all recent cases where members were troubled with scale, and where the conditions were otherwise favorable, they have been advised to adopt this plan. Although boilers can thus be freed from scale more easily and in much shorter time than if they are allowed to dry, it will be found that the men prefer the more unsatisfactory and costly process now in use; a suit of oilskins to protect them from the wet might be found an inducement to convert them to work this method satisfactorily.

"Economizers should be cleaned on the same plan, all the top caps being removed, and the pipes kept full of water while the scale is being detached and converted into mud by light iron scrapers. One-inch gas pipes, to which a serrated disc or pipe couplings about $2\frac{1}{4}$ inches in diameter have been screwed, will do excellent service. When all the pipes have been cleaned, the accumulated mud is removed from below.

"In recent years water-tube boilers have, for certain purposes, been frequently employed, but they give much trouble if the water is sedimentary. In such cases it is suggested that the scale should be similarly removed, if possible, under water, the top tubes being cleaned first, and no water being let out except through the top holes of the tube to be cleaned."

Another matter of importance to steam users is the trouble experienced from the presence of grease in boilers, an evil which has been experienced especially since the introduction of condensing engines. The memorandum says:

"Furnaces, particularly in heavily-fired boilers, have frequently collapsed without any apparent cause, for the film of oil which does the mischief is so thin that it is not easily detected, and it generally gets charred, and disappears as soon as the furnaces have grown hot. The importance of attending to this matter

will be apparent when it is remembered that most hydrocarbon lubricants are exceptionally bad conductors of heat, a thin film of only $\frac{1}{100}$-inch thickness retarding the heat as much as, or even more than, a layer of scale $\frac{1}{10}$-inch thick, or as a steel plate 10 inches thick. If mineral oils have been let into a boiler, they cannot be removed, like vegetable oils, by introducing caustic soda, and the only really effective way of removing them is to allow a thin scale of mineral matter to accumulate, and to remove it together with the adhering oils. By far the better plan is, however, to keep these oils out of the boilers. This is done with reasonable efficiency by passing the feed water through a feed filter. This filter should be arranged so that it can be blown through, whereby the accumulated grease is discharged, and the attendant should be instructed to keep the filtering material as clean as possible.

" Besides using this appliance, it will be worth the most serious consideration of steam users to reduce the amount of lubricating oil used in their cylinders. On many of the largest steamers now running no oil is introduced into the cylinders, except a few drops at the commencement and at the end of each voyage, which often extends over a few weeks. It is found that the moisture in the steam, amounting generally to more than 25 per cent., is an excellent lubricant both for the slide valves and the pistons."

In " Engineering" of June 10 we gave a report of a Board of Trade inquiry with regard to a fatal steam-pipe explosion near Bristol, and on this point Mr. Stromeyer writes as follows:

"An examination of the Board of Trade reports shows that steam pipes frequently explode, due to what is commonly known as water-hammer action. In such cases, it appears that water accumulates in some low-lying part of a steam pipe; its upper surface, where it is in contact with the steam, is hot, but the undisturbed water under this film is cold. A slight agitation of this water, caused, perhaps, by the opening of a stop valve or of a drain cock, may suddenly bring the cold portion of the water into contact with the steam, a sudden condensation takes place, a vacuum is formed into which the column of water rushes with an accelerated velocity, and being then brought to an abrupt

standstill, strikes a most intense blow against the valve or the steam pipe, which, no matter how strongly they are made, in most cases are then shattered. As such accidents occur very suddenly, and often without apparent causes, it was thought well to address a few words of warning to the boiler attendants, particularly as they are the chief sufferers. As pointed out in the 'Advices,' steam pipes can be so designed that no water will find a lodgment in them, and all danger of explosion is removed."

"One very important distinction," Mr. Stromeyer adds, "has for the first time been made in these 'Advices' as regards the causes of collapsed furnaces and how such cases should be treated. When there is shortness of water, the obvious remedy is to raise the water level, and this can be most quickly done by producing artificial priming, cold water being added soon after. If cold water were to be added at first, the immediate result would be a lowering of the water level, and the uncovered plates, which may be nearly red hot, might give way before the water level can be slowly raised to the necessary height by the feed pumps. If the overheated plates are covered with water but separated from it by layers of scale, grease or refuse, it is obviously useless to add more water, and the best remedy must be to cool the fires. Most other 'Instructions' to firemen make a distinction under these circumstances as to whether the furnace plates are red hot or not; but it is clearly impossible for anybody to look at a sooty furnace top exposed either to the flames or to the glare of a clear fire, and to form an opinion as to whether the plate is overheated or not. A fireman could certainly not assure himself on this point, and would therefore be in doubt how to act. Besides, it is dangerous for him to get in front of the furnace."

The memorandum gives some useful information, and deserves the attention of the users of steam power.

SEMI-STEEL.

[Reprinted from "American Machinist."]

EDITOR "AMERICAN MACHINIST:"

Will you please answer the following questions, if you have the desired information at hand?

1. What are the brands of pig iron used in the process of melting in the cupola for semi-steel?

2. What are the proportions of steel scrap used along with pig iron to get a tensile strength from 27,000 to 38,000 per square inch?

3. Do they use crucible-steel scrap or open-hearth steel? Is it in the shape of turnings of borings, or small pieces similar to machinery scrap of cast iron? If turnings of steel or borings, please state how they are charged in cupola.

4. What ratios of fuel are required to melt semi-steel?

Having taken your valuable paper for 18 years, I have not, to my recollection, seen any articles bearing on the required information, but have been led to understand that a New England firm is melting iron and steel in their cupola and are getting better results than they obtained from their air furnace. The claim is made that they get all the way from 27,000 to 43,000 tensile strength per square inch. Are there any works that treat on this subject? If so, please name them. Being a loam molder, these are a few questions, as Mr. Moore would say, "the average molder does not know." I. G.

We referred this question to W. J. Keep, of Detroit, who answers it as follows:

For semi-steel, use any mixture of cast iron that will make strong and soft castings. A test bar one inch square, broken transversely on bearings twelve inches apart, made of such a mixture will show a strength of somewhat over 2,000 pounds. With from 10 to 15 per cent. of steel scrap, the strength will rise to near 3,000 pounds without materially hardening the casting. The grain will be very fine, and will give excellent wearing surfaces. By increasing the scrap to about 20 per cent. the strength can be made to reach 3,500 pounds, and by careful attention to every detail the strength may reach 4,000 pounds. The scrap used is soft, low-carbon cuttings from the edge of boiler plate or punchings from the same stock. Borings cannot be added loose, but if not rusty, by packing 100 pounds in a pine box 12 inches square and 6 inches deep, and nailing the cover on and charging

the box along with pig iron, the box will not burn through until the melting point is reached.

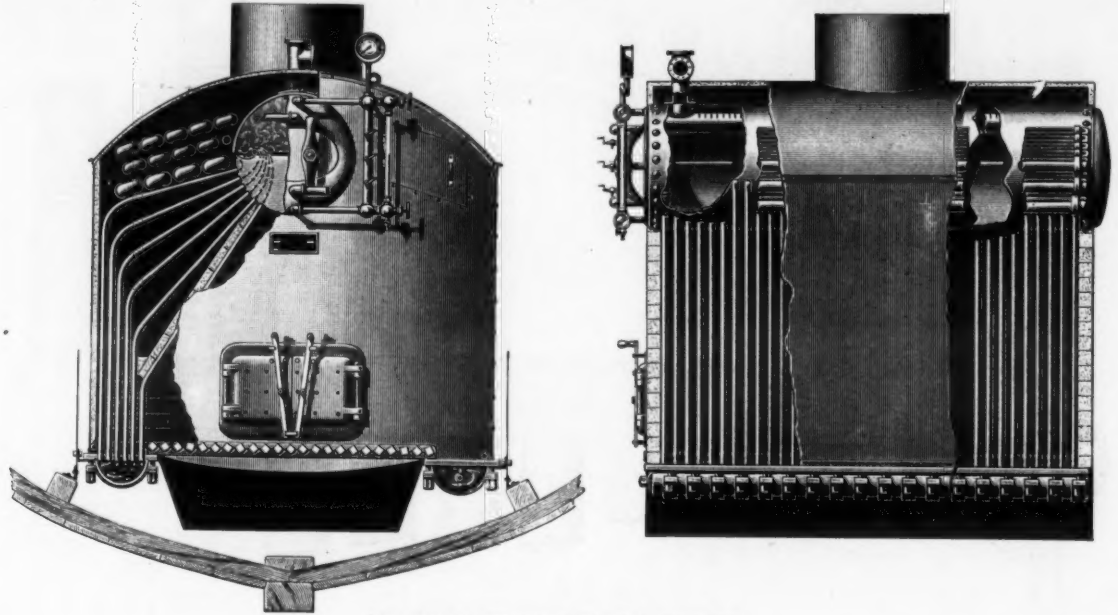
The fuel used in melting must be increased until the heat is sufficient to melt the steel, which requires a much higher temperature than cast iron. The fluid metal must be poured quickly, as it will become thick quicker than cast iron alone. The best way to begin is to add about 10 per cent., and if the result is satisfactory increase the steel scrap. The product remelted again does not give as good results as at the first melting. The benefit seems to result from the mechanical mixture and not in any chemical change. When large quantities of steel scrap are used the castings are likely to be unsound and a sufficient quantity of aluminum is added in the ladle to insure soundness.

A few pieces of ferro-silicon in the ladle will often do as well. Owing to the low price of steel scrap, castings from semi-steel do not cost any more than from cast iron. Tool steel added would make hard castings.

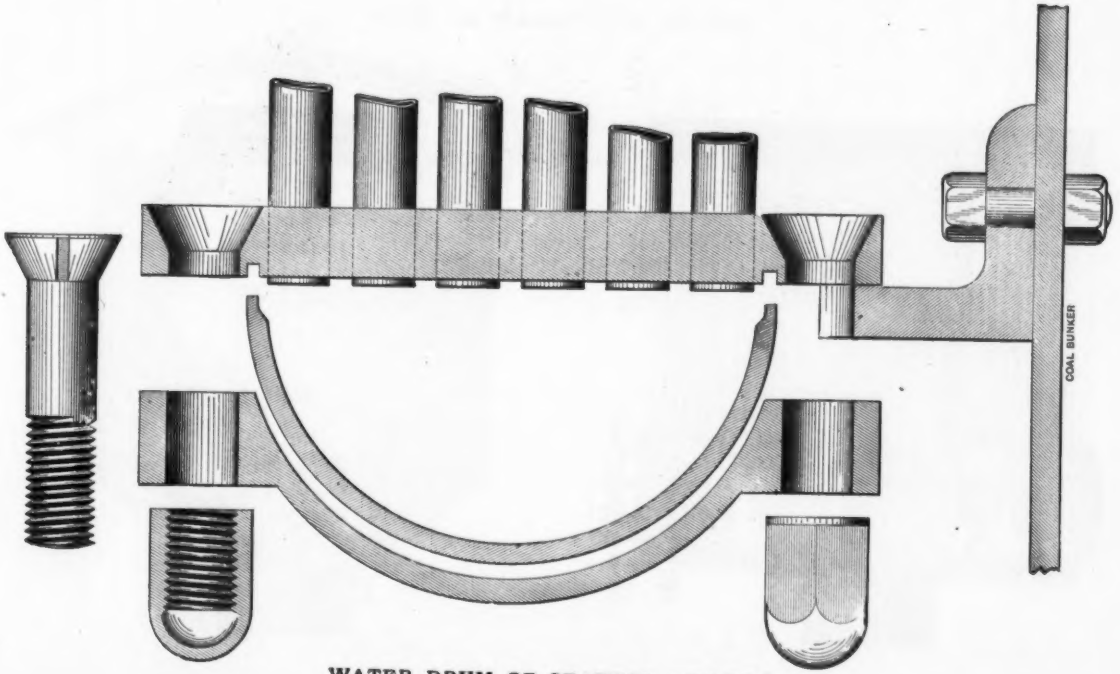
THE SEABURY WATER-TUBE BOILER.

The annexed cuts explain the construction of the Seabury safety water-tube boiler, as largely used for steam yachts and steam launches, and as just completed for the yachts *Endion*, *Margaret* and *Saranac*. The height of the combustion chamber and the arrangement of the rows of tubes are varied to suit the fuel which it is proposed to burn. The feed-water heater is shown in the flat coils of pipe in the uptake on each side of the drum, and serves to increase the efficiency of the boiler by reducing the temperature of the waste products. The baffle of fire brick between the two inner rows of tubes causes the products of combustion to pass to the sides of the boiler and up between the tubes to the smoke pipe.

The boiler has a large heating surface for the space occupied in the boat and for the cubical contents of the boiler casing, and doors through the casing make it easy to keep the tubes clean by using a steam jet. A brush on a chain can be readily run



SEABURY WATER-TUBE BOILER.



WATER DRUM OF SEABURY BOILER.

through the inside of the tubes for cleaning them when they require it. The boiler rests on the upper plates of the lower manifolds, the cylindrical portion of which can be removed. The ease of renewing tubes and making repairs when necessary can be judged from the cuts.

Observation of the engines during the trials of the *Endion* and *Margaret* showed no evidences of water being carried over, and the level of the water in the boilers remained remarkably steady in the glass even when the engine was opened out quickly to full speed. This shows that the circulation and the general arrangement of heating surface is very good. As upon lighting the fires, the flame strikes the inner tubes first, the current is upward in the inner rows and downward in the outer row or rows, the water level in the drum being well above the ends of the outer row of tubes. This gives a very small distance for water to travel to get from the up to the down flow. The tubes are vertical where the hottest flame strikes them, which assists the circulation. The boiler was originally made with down-carrier pipes, but their use was discontinued, as it was found by experiment that it did as well without as with them. This experiment was with a boiler of 810 square feet heating surface doing full duty at 250 pounds pressure, and was made by trying the boiler both with and without plugs in the down-carrier pipes.

The casings of Seabury boilers of this type are made of light sheet steel, about 18 B.W.G. This is lined with 1 inch of magnesia boiler covering and ¼ inch of sheet asbestos. These are held in place by carriage bolts, which draw square sheet steel washers up against the sheet asbestos. The ends which come in direct contact with the flame are lined with fire brick.

LIQUEFACTION OF HYDROGEN.

Permanent gases no longer exist, as Professor Dewar has succeeded in liquefying hydrogen in quantity at the Royal Institution, and showed half a wineglassful of the liquid to Professor Rayleigh. This experiment constitutes a distinct step in advance, as hitherto all attempts to collect liquid hydrogen have failed,

though certain experimenters have, it is claimed, produced it in the form of mist. The density of the liquid is said to be about 0.6, water being unity. The boiling point at atmospheric pressure is about —240 degrees centigrade, or only about 43 degrees above the absolute zero of temperature. When a test tube is plunged in the liquid, its lower portion is soon filled with solidified air.

THE WORLD'S COAL RESERVE.

"Le Moniteur Industriel" has an interesting article on the production and estimated resources of coal of the different countries of the world. It shows that the production is increasing every year, having grown from 408,000,000 tons in 1885 to 513,000,000 tons in 1890, and to 560,000,000 tons in 1894. It has probably reached 600,000,000 tons in 1897. An estimate of the available coal stocks has been made, and on the rate of the increase in production it has been calculated how long these stocks will probably last. The amount of coal yet available can, of course, be estimated only, but in the case of Europe, where the geological research has been very thorough, the estimated figures will not vary much from the actual ones. The estimate for the principal coal producing countries of to-day, is as follows:

	Millions of tons.
Great Britain,	198,000
Germany,	112,000
France,	18,000
Austria-Hungary,	18,000
Belgium,	15,000
Total for Europe,	360,000
United States,	684,000
Total,	1,044,000

In about 500 years the coal stocks of Austria, France and Belgium will be exhausted, and after 700 or 800 years Europe

will be obliged to get its supply of coal from other parts of the world. But there are large resources of the United States which can be drawn upon, and, finally, the coal beds of China, which explorers have pronounced enormous, and which soon will be touched by drill and pick, and forced to give up their black treasure. There is coal enough for generations to come.

NEW FORM OF BOILER WATER GAUGE.

An ingenious method of rendering more readily visible the level in a water gauge for a boiler, and at the same time of making it more secure against fracture under the high steam pressures now so common, is being introduced by Messrs. Richard Klinger and Co., of Fenchurch Station Chambers, 66 Fenchurch street, London. The device consists, in the first place, of a gun-metal frame, having ends corresponding in size and shape to the ordinary gauge glass, and which can be fixed on the same fittings. The body of the gauge is, however, rectangular in shape, having at the front a window closed with very thick glass, which is packed steam tight against the sides of the fitting. The back of this glass is of prismatic form, with the result that the water level is very distinctly marked, owing to the fact that glass and water have not greatly differing indices of refraction for light, whilst that of steam differs much from either. Hence, light entering the gauge above the water level undergoes the total reflection against the prismatic back of the glass, which here shows up like silver; whilst below, the light passes on through the glass into the water, and this portion, therefore, shows up dark. So great is the contrast thus obtained, that the water level can, it is stated, be seen even at a distance of thirty yards from the gauge. The gauges in question are made in both light and heavy patterns; the former, which is intended for pressures up to 90 pounds per square inch, is tested to 300 pounds per square inch before leaving the factory; whilst the heavier patterns, which can be used for working pressures of 300 pounds per square inch, are tested to 600 pounds.

COST OF LARGE-CALIBER AMMUNITION.

The cost of large-caliber ammunition in the present war is very great. A 13-inch gun, firing a projectile weighing 1,100 pounds, consumes 550 pounds of brown prismatic powder, costing from 30 to 33 cents per pound. At the lower price the powder for a single discharge costs $165. The common 13-inch shell is said to cost $116.63; but the armor-piercing projectile costs $418. To these items must be added cartridge bags, primers, freight, etc., amounting to about $15; or $296.63 for the shell discharge, and $588 for the discharge of an armor-piercing projectile. As the 13-inch gun can be discharged about twenty-five times in an hour, the work of one gun for an hour may cost the government about $15,000. The 8-inch gun costs about $65 for each shot; the 5-inch rapid-fire costs $33; the 6-inch breech-loading shot costs about $40, $14 being for the powder; and each round of a Hotchkiss 6 pounder gun is estimated to cost $5.70, and a 1-pounder, $1.12. Whitehead torpedoes cost $2,500 each, and a Howell torpedo, $2,200.—"Engineering News."

BABCOCK AND WILCOX WATER-TUBE BOILERS IN WILSON LINERS.

During July two vessels belonging to the Wilson Line, of Hull, had successful trips, namely, the screw steamers *Rollo* and *Otto*, respectively the fifth and sixth vessels of the same owners to be fitted with Babcock and Wilcox water-tube boilers. The former is an old vessel, built and engined in the year 1870 by Earles' Shipbuilding and Engineering Company, Limited, Hull, being originally fitted with ordinary marine multitubular boilers. The old engines have been converted into quadruple-expansion engines, 19 inches, 26½ inches, 38 inches and 57 inches diameter of cylinders with 36 inches stroke, by the same firm of shipbuilders and engineers, and the vessel has been fitted with two Babcock and Wilcox water-tube boilers capable of supplying steam for 1,100 I.H.P. at 200 pounds per square inch working pressure. Under ordinary conditions, the boilers are arranged to work with natural draft, but they are also fitted with a fan to work with assisted draft when extra power is required. The

speed obtained on the measured mile was 12¾ knots when the engines indicated 1,100 I.H.P. at 73 revolutions per minute. Fourteen and one-half pounds of Yorkshire coal were burned per square foot of grate, and at this rate of working the consumption per I.H.P for all purposes was about 1.5 pounds per hour.

The *Otto* is a new steamer built by the Caledon Shipbuilding and Engineering Company, Limited, Dundee, of the following dimensions: Length b.p., 225 feet; breadth, 32 feet; depth, molded, 14 feet 5 inches, and has a deadweight capacity of 880 tons. The steamer has been specially built for passenger and fast freight service between Hull and Antwerp and Hull and Ghent. The engines are of the triple-expansion type, having cylinders of the following diameters: High pressure, 17 inches; intermediate, 30 inches; low pressure, 52 inches; the length of stroke being 36 inches. Two of the Babcock and Wilcox water-tube boilers, having a working pressure of 225 pounds per square inch, are fitted, their total weight with water being about 70 tons, as compared with about 130 tons for the ordinary multitubular marine boilers. The measured mile at Auckmithie was run over four times, a mean speed of 13.8 knots being obtained with an average I.H.P. of 1,428. A complete four-hours' consumption trial was made at ordinary full speed, and a two-hours' consumption trial was made on the measured mile with the engines full open, and on both trials steam was easily maintained at full pressure. The coal used on the trial was Scotch, and the following results are those taken when the engine was being driven its hardest on the measured mile. The consumption calculations are made on the average I.H.P., no notice whatever being taken of the maximum I.H.P. The day was perfectly calm, and at times not a breath of wind was in the stokehold. The firemen employed had never fired a water-tube boiler before. The feed water remained perfectly steady, and kept level for an hour without requiring any adjustment of the feed valves. No special feed apparatus is fitted.

Total heating surface, square feet	5,500
Total grate area, square feet	117
Average pounds of coal per hour	2,262

Average pounds of ash per hour	118
Average pounds combustible per hour	2,144
Maximum I.H.P.	1,568
Average I.H.P.	1,428
Pounds per I.H.P. per hour	1.58
Pounds combustible per I.H.P. per hour	1.5
Pounds of coal per square foot of grate	19.3
Average speed in knots	13.8
Average revolutions	106
Percentage of ash	6
Temperature of feed water, degrees	147
Pressure of steam in boilers, pounds	225
Pressure of steam in H.P. casing, pounds	220
Pressure of steam in I.H.P. casing, pounds	95
Pressure of steam in L.P. casing, pounds	22

The *Otto* has been built to the rules and under the special survey of the British Corporation, the boilers being constructed also to the Board of Trade requirements. The *Truro*, a sister vessel to the *Otto*, by the same builders, is also fitted with Babcock and Wilcox boilers, and will shortly be completed.—"Engineers' Gazette."

BEFORE AND AFTER THE NAVAL BATTLE AT SANTIAGO.

Our readers who may be searching for amusement in these midsummer days, cannot do better than turn back to our issue of May 12, in which we reprinted the comments of "The Engineer," of London, on "Spain's Armored Cruisers." With the results of the Santiago engagement fresh in mind, it is highly entertaining to read the following:

"We find, therefore, that to all intents and purposes the Spanish *Vizcaya* class are battleships of the second class. * * * The *Cristobal Colon* could, and no doubt will, 'lie in the line' if there is a naval action; she is proof against every sort of shell. Except her and the *Pedro d'Aragon*, now building, which carry 10-inch guns, all the Spanish armored cruisers carry a couple of 11-inch guns; very good pieces, able to penetrate all the armor on the American battleships' guns.

"The American armored cruisers are quite different; they are really armored cruisers. Their belts, instead of being 12-inch

steel, as in the *Vizcayas*, are of 3-inch steel only; their big guns are only of 8-inch caliber. Now, an 8-inch projectile is quite useless against the belts of the *Vizcayas*, or against their barbettes, and in engaging such ships, shell fire alone could be depended on to do anything. Of course, shell fire is the staple attack, but the *Brooklyn* and *New York* can do nothing against the Spaniards with their comparatively feeble 8-inch shell that the Spaniards cannot do against them with a far more powerful gun. It is rank heresy, maybe, but we cannot but hold that there is a tendency to unduly glorify the small quick-fire gun or the medium-sized 8-inch. The chances of hitting are, of course, greater with the smaller weapon, both from its extra rapidity and its extra numerical quantity; but when the big shot does hit, its effect will be, no doubt, far greater."

The latest news from Santiago is that the wrecks of the Spanish cruisers show eight 4-inch, twenty 5-inch, ten 8-inch and only two 12 or 13-inch shot holes above their present water lines. In view of this record, "The Engineer" will probably modify its opinion as to the effectiveness of the 5-inch and 8-inch guns on the American vessels. The fitness of the *Colon* to "lie in the line" seems to be proved, but it is in line with the other wrecks on the Cuban coast, and not in the line of battle.—"Engineering News."

EXPERIMENTS UPON THE DURABILITY OF DIFFERENT METAL COATINGS IMMERSED IN SEA WATER.

In 1896 an interesting test was made at the Brooklyn Navy Yard to determine the relative durability of different protective coatings for metal when immersed in sea water. This test was conducted by Edward Smith & Co., of New York, under the personal direction of Prof. A. H. Sabin, Assoc. M. Am. Soc. C. E., of that firm, and with the permission and aid of the Navy Department. Briefly described, the test consisted in covering thin plates of steel and aluminum with different protective coatings, placing these plates in cages and sinking the cages in about 6 feet of water at the Navy Yard. The plates had an area of about 2 square feet on each side and were so placed in the cages that

both sides were fully exposed to the action of the water, which at this point is very foul with sewage and the collections of the harbor.

The cages were allowed to remain under water for six months and then were hauled out and an examination made of each. Altogether there were 84 plates. The results of this examination, the nature of the different coatings and other details of the test were published in a paper read before the American Society of Civil Engineers on November 4, 1896, by Prof. Sabin. While this test led to a number of interesting conclusions, it showed the need also of further tests; and accordingly, in the summer of 1897, another set of plates were immersed. This second set of plates was removed from the water on July 21, 1898, after an immersion of 13 months, in the presence of a number of engineers and visitors. The accompanying notes of the condition of these plates were taken by one of the editors of this journal, who was present, and examined them upon their removal from the water.

Altogether 133 plates were immersed in this second test. They were placed in six cages. Only two cages and half of a third could be recovered, however, and the accompanying table contains the result of the test of the 72 plates only which these contained. An attempt will be made to dredge up the remaining plates for examination at some future date. Of the 72 plates recovered, twelve were plates which had undergone the 1896 tests and which were immersed a second time. These twelve plates were, therefore, immersed for 19 months altogether. The remaining 60 plates were new when immersed, and, as already stated, were under water for 13 months.

The different coatings with which the plates were covered are described in the table, and with a brief explanation these descriptions will be clear to nearly everyone. The ordinary oil and resin varnishes are made by compounding certain fossil resins with various proportions of refined linseed oil, and the essential differences in varnishes are due chiefly to the kinds of resin used and the proportion of oil. For convenience it is customary to assume 100 pounds of resin as a unit. A 20-Kauri varnish, therefore, means a varnish resulting from compounding 20 gal-

TABLE SHOWING RESULTS OF TESTS OF PROTECTIVE COATINGS APPLIED TO STEEL AND ALUMINUM PLATES IMMERSED FOR THIRTEEN MONTHS* IN SEA WATER AT BROOKLYN NAVY YARD.

No. of plate.	Character of vehicle.	Character of pigment.	Preparation.	Condition of plate and coating.
			Aluminum Plates.	
151	20 Kauri varnish	None.	Air dried.	Edges blistered; no considerable corrosion.
152	30 " "	"	"	Covering one-half gone; much corrosion.
153	40 " "	"	"	Covering mostly gone; badly corroded.
154	IXL No. 2 varnish	"	"	Covering half gone; not badly corroded.
155	Spar varnish	"	"	Covering mostly soft; some corrosion, not deep.
156	" "	"	"	Somewhat more corroded than plate 155.
157	Durable metal coating	"	"	Hard; no corrosion; 20 per cent blistered at edges.
158	Pipe coating, baked	...	...	Good condition.
159	" " "	...	...	Good condition.
160	30 Kauri varnish	White zinc.	Air dried.	Quite hard; top, good condition; bottom, blistered.
161	40 " "	"	"	Good condition.
162	30 Zanzibar varnish	"	"	Excellent condition; no corrosion; no blisters.
163	Spar varnish	"	"	Several large blisters; not deeply corroded.
164	20 Kauri varnish	None.	"	Covering three-fourths gone; badly corroded.
165	30 " "	"	"	Covering badly destroyed; much corrosion.
166	40 " "	"	"	Covering considerably blistered; not much corrosion.
167	IXL No. 2 varnish	"	"	Covering considerably blistered; somewhat corroded.
168	Spar varnish	"	"	Coating soft; some blisters; not badly corroded.
169	Durable metal coating	"	...	Hard; considerably blistered; very little corrosion.
170	30 Kauri varnish	White zinc.	Air dried.	Hard; few blisters; some corrosion.
171	40 " "	"	"	Considerably blistered and corroded.
172	30 Zanzibar varnish	"	"	Hard; no corrosion; no blisters.
173	Spar varnish	"	"	Hard; no corrosion.
174	Pipe coating, baked	...	...	Good condition; no corrosion; no blisters.
175	" " "	...	...	Good condition.
...	Mitchell's	White enamel.	...	Excellent condition.
			Steel Plates.	
251	40 Kauri varnish	Ultramarine blue.	Air dried.	Many small blisters; little corrosion.
252	Raw oil	" "	"	Coating practically gone; uniformly corroded.
253	20 Kauri varnish	Graphite.	"	Blistered slightly; very little corrosion.
254	30 " "	"	"	Few small blisters; no corrosion.
255	40 " "	"	"	Many small blisters; no corrosion.
256	Raw oil	"	"	Coating destroyed.
257	20 Kauri varnish	Keystone.	"	Many pin-head blisters, but generally good.
258	30 " "	"	"	Pin-head blisters; no corrosion.
259	40 " "	"	"	Pin head blisters; no corrosion.
260	Raw oil	"	"	Coating destroyed; badly corroded.
261	20 Kauri varnish	Red iron oxide.	"	Blistered some; not badly corroded.

257	20 Kauri varnish	Keystone.	"	Many pin-head blisters, but generally good.
258	30 " "	"	"	Pin-head blisters; no corrosion.
259	40 " "	"	"	Pin head blisters; no corrosion.
260	Raw oil	"	"	Coating destroyed; badly corroded.
261	20 Kauri varnish	Red iron oxide.	"	Blistered some; not badly corroded.
262	30 " "	" " "	"	Many small blisters; some corrosion.
263	40 " "	" " "	"	Many pin-head blisters; some corrosion.
264	Raw oil	" " "	"	Coating practically destroyed; badly rusted.
265	" "	Red lead.	"	Coating mostly gone; considerable corrosion.
267	" "	Prince's metallic.	"	Coating practically destroyed; badly rusted.
268	" "	Purple oxide.	"	Coating practically destroyed; badly rusted.
269	Eureka paint	...	"	Coating badly destroyed; badly rusted.
270	Detroit graphite paint	...	"	Coating destroyed; badly corroded.
272	Bowles paint	...	"	Good condition; few blisters.
273	Rahtjens paint	...	"	Coating badly gone; considerable corrosion; few barnacles.
274	McInnis paint	...	"	Very good condition; no barnacles.
275	International Holtzapfel	...	"	Coating badly gone; considerably corroded; small barnacles.
277	Red lead and white zinc	...	"	Soft, gone in spots; corroded on edges.
278	" " " " "	...	"	Soft, gone in spots; corroded on edges.
281	20 Kauri varnish	None.	"	Discolored on edges by rust; not deeply rusted.
282	30 " "	"	"	Small blisters; not deeply corroded.
283	40 " "	"	"	Pin-head blisters; not deeply corroded.
284	30 Manila varnish	"	"	Numerous small blisters; not deeply corroded.
285	30 Zanzibar varnish	"	"	Many pin-head blisters; little corrosion.
286	Spar varnish	"	"	Badly destroyed; considerable corrosion.
287	IXL No. 2 varnish	"	"	Many pin-head blisters; not much corrosion.
288	Raw oil	"	"	Coating destroyed; badly corroded.
289	Durable metal coating	...	"	Many small blisters; little corrosion.

Steel Plates Reimmersed After 1896 Test.

1	20 Kauri varnish	Flake white.	Air dried.	Rusted on edges; discolored; good condition otherwise.
2	20 " "	"	Baked.	Rusted on edges; discolored; good condition otherwise.
16	20 Manila varnish	White zinc.	"	Some blisters; one side considerably corroded.
18	8 " "	Flake white.	"	Hard; pretty good condition.
20	30 Zanzibar varnish	White zinc.	"	No blisters; no corrosion.
22	20 " "	" "	"	Few blisters; some corrosion; hard.
35	Sabin process pipe coating enamel	...	...	Some corrosion on one edge; otherwise good condition.

Aluminum Plates Reimmersed After 1896 Test.

113	Sabin process pipe coating enamel	Two small blisters; otherwise good condition.
104	White zinc ground in varnish, one side baked	Three or four small blisters; otherwise good condition.
122	" " " " " " " "	Three or four small blisters; otherwise good condition.
105	Chromium oxide ground in varnish, one side baked	Few small blisters; generally excellent condition.
124	Spar varnish, one side baked	Two or three small blisters; no considerable corrosion.

* The twelve plates from the 1896 test were immersed six months longer than the others, or nineteen months altogether.

lons of oil with 100 pounds of Kauri resin. A similar terminalogy is adopted for varnishes made of Zanzibar or Manila resin. Where the coating is described as "air dried" it is meant that it was allowed to dry on the plate at ordinary temperature, and where it is described as "baked" it is meant that a heat of 215 degrees to 240 degrees F. was employed to bake the coating on the plate.

In examining the plates they were simply removed from the cages, washed to remove the slime and loose marine growths, and inspected while wet. Only a few moments were given to the examination of each plate, as it is intended to examine them more carefully when they have thoroughly dried. Until the results of this final study are collated it is, perhaps, best not to pass opinion upon the comparative behavior of the different coatings in detail.

One or two broad conclusions, however, seem to follow from the facts given. It is pretty plain:

(1) That whatever pigment is used, a more durable coating for marine work results if varnish is used as the vehicle than if oil is used.

(2) That a varnish coating or a pigment and varnish coating seems to endure sea water better when baked on than when merely air dried on.

(3) That white zinc is probably acted upon as little as any pigment which was used in the test.

(4) That enamel coatings baked on at high temperatures are apparently the most durable of any.—"Engineering News."

LIGHT-DRAUGHT RIVER GUNBOATS.

In view of Mr. Charles Ward's paper on this subject in the February JOURNAL, and the note on page 509 in the May number, our readers will be much interested in the following discussion of the relative merits of the screw turbine and the ordinary propeller for light-draught vessels. It has been sent to the JOURNAL by the representative in this country of Messrs. Thornycroft & Co., and refers especially to the note in the May number:

We think the statement is a very unfair one, and shall be glad if you will arrange, if possible, to have a further statement inserted in the next number.

The figures given for speed and I.H.P. are correct, although they are selected to show the Yarrow boat to most advantage.

For example, the speed given for the *Melik*, of 11.97 knots, was the mean speed estimated from revolutions during a run of two hours, and the I.H.P., 461, was the mean of measurements taken at half hourly intervals.

As there was some variation of steam pressure during the two hours, the I.H.P. was not, as it happened, fairly averaged.

The results obtained during the six runs on the measured mile on the same occasion give a much more reliable relation between speed and power, because the I.H.P. was measured on each run.

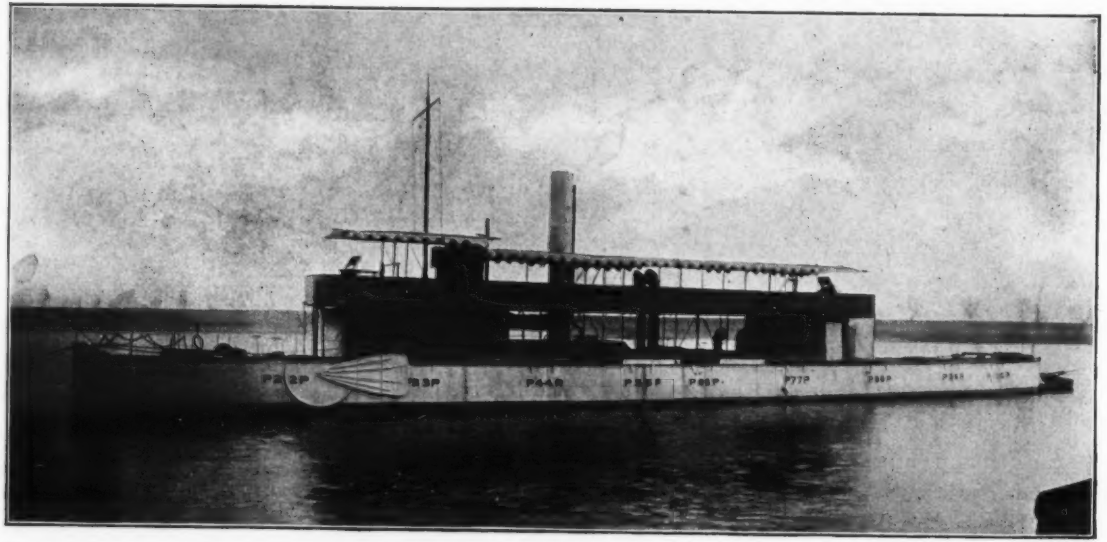
These runs showed a mean speed of 12.14 knots for 453 I.H.P., but the comments made by the author of the note upon the figures are what we object to. He says, "Considering that the *Melik* has less displacement and finer lines than the *Sultan*, it may be roughly taken that the results of the two systems when going ahead are practically equally good. It must, however, not be lost sight of in making this comparison, that the turbine propeller is utterly inefficient for going astern or for stopping headway."

The coefficient $\frac{V^3 D^{\frac{2}{3}}}{\text{I.H.P.}}$ for the Yarrow boat is 87.2, and for the *Melik*, taking even the less accurate figures of the two-hour trial, it is 100, and taking the correct figures obtained on the measured mile it is 107. This makes due allowance for the difference in displacement.

The Yarrow boat would have taken 570 I.H.P. to do 12.14 knots, assuming that the power would have increased in the ratio of the speed cubed only, which is probably underestimating it.

As the Thornycroft boat, which was only 5.6 tons lighter, did this speed with 453 I.H.P. instead of 570, we do not see that it can fairly be said the results of the two systems are practically equal when going ahead.

The revolutions of the engines were, we believe, nearly 100



H. M. S. "WOODLARK"

less per minute in the Thornycroft boat. They were 282 for 12.14 knots. This we consider an advantageous feature.

It is quite untrue to say that the Screw Turbine is "utterly inefficient for going astern or for stopping headway."

By our contract we were bound to make the vessels well under control going astern, and they not only went astern at a speed of 4¾ miles per hour, but could be steered going astern.

We enclose a photograph of the *Woodlark* for publication, but fear that on account of the description of the *Heron*, a fuller description of the *Woodlark* would be so similar as to be uninteresting.

The speed of the *Woodlark*, viz: 15.4 miles per hour on official trial, carrying 30 tons load, is a feature of interest.

She is the fastest river gunboat afloat, and, so far as we know, the speed could not have been attained under the conditions of trial with any other propeller than the screw turbine.

A COMPARISON OF BRITISH AND AMERICAN NAVAL VESSELS.

[Reprinted from "Engineering News."]

The following comparison by an English naval expert of the vessels, guns and armor in the British and United States Navies, we find in the New York "Tribune," credited to the London "Mail." It appears to be a very fair and unprejudiced statement, and is, so far as we are aware, in accordance with the actual facts. The British Navy is certainly in advance of all others in the world in its use of the wire-wound gun, which, by permitting higher pressures, larger powder charges and longer barrels, sends its projectiles home with a force which ordinary built-up guns of the same caliber cannot equal. The critic's remarks respecting the speed of battleships are also noteworthy:

"American guns are not, I take it, so good as ours. The 60-ton weapon is a fine and powerful gun and has stood the strain of prolonged firing, but it is not better than the British 67-ton gun and is inferior, both in rapidity of fire and penetration through armor, to our 46-ton wire weapon. There can be little doubt that our 6-inch and 4.7-inch weapons of the quick-fire type are ahead of anything now manufactured in the United States.

The British-built *New Orleans* is pronounced by American naval officers in the West Indies the best cruiser of her size in the United States Navy. Her guns have excited particular admiration, owing to their simplicity, accuracy and rapidity of fire.

"When we turn from guns to projectiles and armor we are upon less certain ground. Two years ago the American Carpenter and Wheeler-Sterling shells were better than anything made in England. It is possible that to-day they are ahead of our projectiles, though with the very great attention given to this point by British manufacturers recently, it is not altogether likely. Our Hadfield projectiles are, I believe, among the very best. Still, the American Navy is probably at this present minute supplied with better armor-piercing projectiles than the British Navy, for the reason that the United States did undoubtedly get ahead of us.

"In the matter of armor plates England fell behind because, for some reason or other, the Admiralty in our earlier Harveyized plates did not use nickel. The Americans adopted a nickel steel, which has performed wonderfully in trials. But here again, I am glad to say, we have advanced greatly. The Krupp gas-hardening process, which has been adopted by our three great armor-making firms, when applied to nickel-steel plates, such as we now use, gives splendid results. The firm of Vickers has particularly distinguished itself for the armor which it has turned out in the last few months. Nor are Brown and Cammell behind their enterprising rivals.

"The point in which American ships excel ours is in battery. It is well known that, ton for ton, the United States warship is beaten in armament only by the new ships now constructing for Germany, a young and audacious Power. Taking two new ships, British and American, these are the armaments:

Canopus (British).	*Alabama* (American).
Four 12-inch.	Four 13-inch.
Twelve 6-inch.	Fourteen 6-inch.
Ten 12-pounders.	Seventeen 6-pounders.
Six 3-pounders.	Six 1-pounder.
Eight Maxims.	Four Maxims.
Four torpedo tubes.	Four torpedo tubes.

"The American ship has a much heavier battery. Though, as has been said above, the British 12-inch gun shoots harder than the American 13-inch, the projectile of the American gun is 400 pounds heavier than that of our gun. Probably with crews of equal efficiency the American ship would win on guns alone, if her weapons were of the most recent type. She has two more 6-inch quick-firers, and the 6-inch gun is a very formidable and useful weapon.

"In the matter of ammunition the British ship is better supplied for her heavy guns. She is no better supplied with 6-inch shells. And it must be remembered that she is 1,400 tons larger.

"In armor the difference is most striking. These are the facts, set forth side by side to afford a contrast:

British.	American.
Side—belt, 250 feet by 18 feet and 6 inches thick.	Belt, 220 feet by 7½ feet, from 16½ to 9½ inches thick. Above this a belt 140 feet long by 8 feet broad, 5½ inches thick. Above this another tier of armor, 140 feet long by 7 feet 6 inches broad, 5½ inches thick.
Heavy guns—Barbettes, 10-inch; shields, 6-inch, sloped.	Barbettes and turrets, 15 to 17 inches.
6-inch guns—6-inch casemates.	5½ inches.
Protective deck—Two, one 1-inch, the other 2½-inch.	One, 2¾ to 4 inches.
Armor on ram—2 inches, a broad belt, covering the ship forward.	4 inches, a narrow belt.

"It will be seen that the American ship is, beyond question, better protected than the British vessel. In the American the armor virtually sheathes the whole vessel amidships. In the British ship the armor is only a patch—though a large patch.

Moreover, there is no thick armor on the water line, as we find in the American.

"In speed and coal supply the British *Canopus* has a great advantage. Our ship is nominally good for 18¾ knots, and carries 1,900 tons of coal. The American is 2¾ knots slower, and carries 1,200 tons of coal. In practice the difference of speed should be about two knots. Great importance is attached in this country to speed, and very rightly. We must always force the fighting if war comes, and our ships must be able to catch their enemies. They are none too fast, as matters stand, for France has smaller battle ships than the *Canopus*, now nearly ready for sea, with engines as powerful as hers.

"It would be wise from our point of view to class the *Canopuses* as armored cruisers of the finest type. Then, perhaps, we should hear less of the superiority, in actual fighting points, of such ships as the *Alabama*.

"Turning to our cruisers, it does appear that the Americans are ahead of us. The *Brooklyn*, for example, is much more heavily armed than the *Powerful* of about her own date; is very nearly as fast, and in coal endurance is equal to the British. Our smaller cruisers are enormously below the Americans of their own size in armament. I have always held with our American friend that in war the object should be to kill your enemy as quickly as possible, before he kills you. The more guns you can carry the more likely you are to hit the enemy and to kill his men.

"It is said: 'Oh, but we carry so much more ammunition.' No doubt we do, but the question is this, 'Would it not be wiser to copy other Powers, and translate this ammunition into guns?' I notice that the newest Russian cruisers, of the size of our *Hermes*, carry one more 6-inch gun, and have 180 rounds of ammunition per gun, against our ship's 200. Yet the Russian ship will steam 23 knots, natural draft, and ours only 20½.

"Take the *Olympia* as another example. She is just about the size of our *Eclipse*. But she is 1½ knots faster; carries 300 tons more coal; has 4-inch armor on her big guns; a deck much

thicker than the *Eclipse's*, and a battery out of all proportion more powerful. Here are the figures:

Eclipse.	*Olympia.*
Five 6-inch quick-firers.	Four 8-inch.
Six 4.7-inch quick-firers.	Ten 5-inch quick-firers.
Eight 12-pounders.	Fourteen 6-pounders.
Eleven small.	Ten small.
Three torpedo tubes.	Six torpedo tubes.

"Summing up, then, we may pronounce our battleships in important respects better than the American, our guns much better, our projectiles as good, our armor as good, and our cruisers much worse."

SUPPLEMENTARY PROGRAMME FOR NEW SHIPS FOR BRITISH NAVY.

[The following extract from an editorial in "Engineering" of July 29, gives an idea of the new British ships which are soon to be laid down.—Ed.]

We turn from this question, to which we have given perhaps undue prominence lest silence might be misconstrued, to the main point of Friday's debate, the composition of the fleet and the design of vessels included. The vessels embraced by both the first and the supplementary programmes, make a very respectable total of new construction for one year—seven battleships, eight cruisers of the first class, practically all armored, four gunboats and twelve destroyers, the cost completed being fifteen millions sterling; but the House and the country look with equanimity to this large addition made to our fleet at one stroke of the pen. Nothing so clearly proves the progress of public education on the importance of sea power. These fifteen millions will, it is true, be spread over three, if not four years; but we have already incurred heavy financial responsibilities in respect of other work now in progress, and new ships will be brought forward in the future as circumstances require.

Here is a list of vessels building or to be laid down, showing separately the vessels launched but not far advanced, vessels building, and vessels yet to be laid down:

—	Launched.	Building.	Not commenced.
Battleships	4	5	7
First-class cruisers	4	5	8
Second-class cruisers	5	1	...
Third-class cruisers	7	...	...
Gunboats or sloops	...	4	4

All destroyers and the vessels delivered for trial are excluded. Four of the first-class cruisers mentioned as "building" have only recently been commenced. They are known as the *Cressy* class [which we described in the May JOURNAL, page 540]. Two more of these cruisers included in the vessels not commenced are about to be ordered, tenders having been submitted by contractors on Monday. Two other cruisers will be similar to the *Powerful*, but with vertical armor on the broadside, to which we shall refer presently; while of the other four, to be given out later, details of design are not yet available.

These new *Powerfuls* are, as Mr. Goschen said, to compare with such vessels as the *Jeanne d'Arc*, and there can be no doubt that they are in every respect superior to that French armored cruiser. They will be practically of the same dimensions as the *Powerful:* 500 feet long between perpendiculars, 71 feet beam extreme, 26 feet mean draught, and 14,100 tons displacement; speed 23 knots, with natural draft, and 30,000 indicated horse power. These are "mighty" cruisers, as the First Lord called them, but the displacement was required to give them the necessary fighting qualities—guns, protection and radius of action.

The *Jeanne d'Arc* is smaller, and depends for her 23 knots on forced draft. She has only two 7.6-inch guns, eight 5.5-inch quick-firing guns, twelve 3.9-inch guns, with a number of machine guns; while the new *Powerfuls* will have two 9.2-inch guns, with armored shields, sixteen 6-inch quick-firing guns (four more than the original *Powerfuls*), fourteen 12-pounders, and other small guns, although fewer than the French ship.

The new *Powerfuls* will have 6-inch side armor, associated

with strong steel decks, resembling in protection the *Cressy* cruisers and *Canopus* battleships. The new ships will have capacity in the bunkers for 2,500 tons of coal and will carry on trial 1,250 tons of coal. This will form a magnificent class, and it is to be hoped that the four other ships to be laid down will be made of the same class, or at least equal to the *Cressy*.

As to the battleships on the list, the four launched are of the *Canopus* class, of 12,950 tons and 18¼ knots speed. Two of those building are of the same class and three others are of the *Formidable* class, of 15,000 tons and 18 knots speed, the difference between the two classes being that a greater area is protected by armor. Three of the vessels not yet commenced will also be of the *Formidable* class; and as to the four others of the supplementary programme, they are to be of rather less armor but more speed than the *Formidables*, rather less draught, and "more calculated to pass through the Suez Canal without lightening, and will be designed to meet those ships which they are likely to encounter in the waters to which they are sent." They will therefore resemble the *Canopus* more than the *Formidable*, but no decision has yet been made.

EVAPORATING PLANT OF U. S. S. *RAINBOW*.

The *Rainbow* is the second of two ships purchased by the Government to be fitted out as distilling ships. The first of the two, the *Iris*, is nearing completion at the Norfolk Navy Yard. Work on the *Rainbow* at the New York Yard is in hand.

The following description of the evaporating and distilling plant will be understood to refer to the *Rainbow*, but that of the *Iris* differs from it in minor details only.

The evaporators, twelve in number, together with the distillers or condensers, of which there are four, three feed and two brine pumps and three feed heaters, are placed between decks in a compartment just abaft the engine room. The circulating pumps for distillers, which are also used for discharging fresh water from storage tanks, are located in the port after end of the engine room.

There will be provided a total storage capacity of 700 tons; viz: 400 tons in the double bottom and about 300 tons in tanks in the hold space immediately below the evaporating plant.

Evaporators.—There will be twelve evaporators, arranged in four sets of three, there being two sets of three on each side of the ship, space being left between these sets for the distillers with their air pumps, and for the brine pumps.

The evaporators are of the type ordinarily used by the Bureau of Steam Engineering, with cylindrical steel shells, 5 feet 6 inches inside diameter, by 6 feet 2½ inches between heads, and straight brass tubes, 1½ inches outside diameter, expanded at each end into the tube sheets of steam manifolds or heads. The front steam head is bolted to a casting riveted to heads of evaporators. This casting contains at the top a pipe with nozzles for steam, communicating through openings of proper area with the steam head, and at the bottom similar openings and passages for the water condensed in the tubes. This arrangement insures that the

tubes may be removed without disturbing any pipe connections whatsoever.

The evaporator shells are designed for a working pressure of 50 pounds, and the coils and all parts subject to full boiler pressure for a working pressure of 150 pounds per square inch. Each will contain about 320 square feet of heating surface.

The tubes of each evaporator will be arranged in two separate nests, so that one-half can be withdrawn for scaling or repair while the other half is left in position, if so desired. Blank bonnets are provided, closing up the steam and drain openings, so that one-half the tubes of any evaporator may be withdrawn for scaling or repair, while the other half remains in operation.

It is the intention to operate each of the four sets of evaporators on the triple-effect system ordinarily, but the piping between the evaporators of each set and to the distillers or condensers is so arranged, and valves so disposed, that any one of a set may be cut out and the remaining two worked in double effect, or so that all may be worked in single effect. The steam or vapor pipes between the first and second, and the second and third evaporators of each set are 6 inches in diameter; between the third evaporator of each set and the condensers, the pipes are 8 inches in diameter.

Distillers or Condensers.—For condensing the steam or vapor from the low-pressure evaporators, or from all the evaporators when worked single effect, four distillers or condensers are provided, two on each side of the ship, each fitted with an air pump, upon which it is mounted. The distillers on each side are so connected that the steam may be passed into either one or into both.

They are of the usual design of auxiliary condensers as used in naval vessels, the tube ends being packed with cotton tape and screw ferrules. The inlet and outlet nozzles, 6 inches in diameter, for circulating water are so placed that the distiller bonnets can be removed and the tube ends exposed without breaking the pipe connections. Each condenser has a 9-inch nozzle for steam connection from the evaporators, and a 2-inch opening for a drain connection from the low-pressure evaporators, to be described below.

The cooling surface of each condenser is about 300 square feet.

Feed Heaters.—There will be three feed heaters, each containing about 52 square feet of heating surface. The shells are of cast iron, and each contains three coils of copper tubing, $1\frac{5}{8}$ inches outside diameter, tinned inside and outside, of 10 convolutions, arranged so as to be readily accessible for scaling and repairs. Each heater is fitted with the necessary nozzles and connections with stop valves for inlet and outlet of feed water for evaporators, and for inlet and outlet of exhaust steam from pumps and for the drain water from high-pressure evaporator tubes. One of the feed heaters, in addition to the connection with the exhaust steam and drain water just mentioned, has another inlet and outlet with separate valves for the drain water from coils of low-pressure evaporators.

Feed Pumps and Pipes.—There are three Davidson 6-inch and 4-inch × 8-inch steam pumps for feeding the evaporators. These pumps draw from the overboard discharge pipe for the condenser circulating pumps. Each pump discharges into a 2-inch pipe leading to one of the feed heaters, with valves so arranged that the feed heater may be cut out and by-passed, and also so that evaporators operated under a vacuum may be fed by gravity. There is fitted a communicating pipe between the feed pump discharge pipes to feed heaters, with valves so located that any one of the pumps may discharge through any one of the feed heaters.

The feed outlet from each heater is 2 inches diameter, and branches into two $1\frac{1}{2}$-inch feed mains, one for the six evaporators on each side. Each $1\frac{1}{2}$-inch main divides into two $1\frac{1}{4}$-inch branches, each of which branches will lead to the two evaporators on each side of the ship worked at the same pressure. This arrangement, being repeated for each of the feed outlets from the feed heaters, will result in three separate mains similarly branched, each main feeding evaporators which are worked at the same pressure. The feed outlet for each feed heater will, however, have a 2-inch connection and stop valve to each of the feed mains above described, so that any pump may feed any evaporator.

Traps and Drains.—The tubes of each evaporator will be drained by a Nason trap. These traps are fitted with by-pass pipes and valves, and discharge into each of two drain mains, with valves to direct the flow to either. Of these mains, one is piped to join the exhaust pipe from the pumps. Beyond this junction the exhaust pipe, which is 4 inches in diameter, will have branches with stop valves to lead into each of the feed heaters. The drains from the feed heaters are collected into a 4-inch pipe leading to the auxiliary condenser and to the boiler feed tank, with pipe branches and valves to direct the water to either one. There will also be a by-pass pipe with valve to lead the exhaust and the drain water to the condenser or feed tank without passing through the feed heaters.

The second drain main is piped to lead into one of the feed heaters, and the drain from this feed heater will, under these circumstances, be piped to lead to the condensers. There will be by-pass pipes and valves, so that drain water passing through this main may be directed into the condensers without flowing through the feed heater.

Brine Pump and Connections.—There are two pumps, similar in all respects to the feed pumps, for pumping brine from the evaporators. These pumps are on opposite sides of the ship, each piped to drain the hot brine from the six evaporators on the same side, and discharge it overboard through the outboard delivery of the condenser circulating pumps. By-pass pipes and valves are fitted between suction and discharge pipes at each brine pump, so that the evaporators under pressure exceeding atmospheric may be blown out without using the pump. The brine-pump suction pipe is made 2 inches diameter throughout, the branches from the evaporators, each fitted with a packed plug, being $1\frac{1}{4}$ inches in diameter.

Circulating Pumps and Connections.—There are two single cylinder Davidson pumps, 10-inch and 14-inch × 14-inch, for circulating sea water through the condensers, and also for discharging fresh water from the storage tanks and double bottom. They are located in the port after end of the engine room. The sea-suction valve is fitted close to the pumps, and suction branches

lead from it to each pump, each guarded by double valves, to minimize the chance of salt-water leaks into the fresh-water suction. The fresh-water suction pipe will be at the opposite end of the pumps, branches to the pumps being fitted with double stop valves as on the salt-water side, and for the same reason. From the fresh-water suction main two branches are led, one connecting with the double-bottom suction manifolds, and the other with the tank-suction manifolds, of which there are two, located in the engine room, one on each side of the middle line of the vessel.

The circulating pumps discharge to a distributing manifold with branches and valves for salt-water discharge to distillers, and for fresh-water discharge to deck. These pipes will be so led and valves so arranged that one pump may discharge to the condensers while the other is delivering fresh water to hose manifolds on upper deck. The discharge pipes from the air pumps will combine into a common main and deliver into a pipe terminating in the fresh-water suction main of the circulating pump. At this point there will be a stop valve at each side of the discharge pipe from air pump, so that the plant may continue in operation, using one of the circulating pumps, while the other is distributing fresh water. Between the fresh-water discharge to deck and the fresh-water suction main a by-pass pipe with valve is arranged for filling the storage-water tanks from hydrant on shore, and the air-pump discharge pipe above mentioned joins this by-pass pipe.

The fresh-water discharge pipes to deck terminate at each side of the ship in a discharge manifold, each with eight $2\frac{1}{2}$-inch hose valves and hose connections.

The storage-water tanks in the hold aft of the engine room are arranged in two tiers, the upper tanks being connected by a pipe to the tanks immediately below. From each of the lower tanks a $2\frac{1}{2}$-inch suction pipe will lead to the suction manifold in the engine room on the same side of the ship.

Air Pumps and Connections.—Each distiller will be mounted on a 6-inch and 8-inch $\times$ 10-inch air pump of the Davidson pattern.

Each pump will draw from its condenser and discharge to the fresh-water tanks as described above.

Steam and Exhaust Pipes.—The main steam pipe of the evaporating plant will be 7 inches diameter, decreasing in diameter as branches are taken off. There will be a 2½-inch branch with stop valve to the steam manifold of each evaporator, and pipe branches of proper diameter for the various pumps. The live steam branches to the first-effect evaporator of each set of three will be fitted with a reducing valve. The exhaust branches from the different pumps will unite in a 4-inch main. This main will lead fore and aft in the evaporator room, and will have 2½-inch branches and stop valves to direct the exhaust steam into the live steam pipes of the first effects, on the low-pressure side of the reducing valves aforementioned. There is provided also a branch of the full size of the exhaust pipe with stop valve, so that the exhaust steam may, if desired, be led to the feed heaters, there being provided an athwartship pipe of 4-inch diameter joined at each end by the drains from the high-pressure evaporator tubes, this main being connected with the feed heaters through 2½-inch branches with stop valves, as described under the heading of "Traps and Drains." There is fitted also a by-pass pipe with stop valve, so that the exhaust steam and drain water from high pressure evaporators may by-pass the heaters and be led directly to the auxiliary condenser or the feed tank.

SHIPS.

UNITED STATES.

Battleships 10, 11 and 12, Maine, Missouri and Ohio.—The following extracts are from the circular defining chief characteristics of three seagoing coast-line battleships, authorized by Act of Congress, approved May 4, 1898, making appropriations for the naval service for the fiscal year ending June 30, 1899, and for other purposes.

The following is an extract from the Act above referred to:

"That for the purpose of further increasing the naval establishment of the United States, the President is hereby authorized to have constructed by contract, three seagoing coast-line battleships carrying the heaviest armor and most powerful ordnance upon a displacement of about eleven thousand tons, to have the highest practicable speed for vessels of their class, and to cost, exclusive of armor and armament, not exceeding three million dollars each. . . . . *Provided*, That . . . . not more than two of said battleships shall be built in one yard or by one contracting party, and the contracts for the construction of each of said vessels shall be awarded by the Secretary of the Navy to the lowest best responsible bidder, having in view the best results and the most expeditious delivery; and in the construction of all of said vessels, all of the provisions of the Act of August third, eighteen hundred and eighty-six, entitled 'An Act to increase the naval establishment,' and amendments subsequently made thereto as to materials for said vessels, their engines, boilers, and machinery, the contracts under which they are built, except as to premiums, which are not to be offered, the notice of any proposals for the same, the plans, drawings and specifications therefor, and the method of executing said contracts, shall be observed and followed, and said vessels shall be built in compliance with the terms of said Act, save that in all their parts said vessels shall be of domestic manufacture, and, subject to the provisions hereinafter made, one and not more than one of the aforesaid seagoing battleships shall be built on or near the Pacific Ocean or in the waters connecting therewith; *Provided*,

That if it shall appear to the satisfaction of the President of the United States from the biddings for such contracts when the same are opened and examined by him, said vessel can not be constructed on or near the coast of the Pacific Ocean at a cost not exceeding four per cent. above the lowest accepted bid for the other battleships provided for in this Act, he shall authorize the construction of said vessel elsewhere in the United States, subject to the limitations as to cost hereinbefore provided.

"CONSTRUCTION AND MACHINERY.—On account of the hulls and outfits of vessels and steam machinery of vessels heretofore and herein authorized, thirteen million six hundred and forty-eight thousand four hundred and seventy-three dollars: *Provided*, That section two of the Act entitled 'An Act to increase the naval establishment,' approved August third, eighteen hundred and eighty-six, be, and the same is hereby, amended so as to read as follows:

"'SEC. 2. That in the construction of all naval vessels the steel material shall be of domestic manufacture, and of the quality and characteristics best adapted to the various purposes for which it may be used, in accordance with specifications approved by the Secretary of the Navy.'"

The following is an extract from the Act of August 3, 1886:

"SEC. 7. That the Secretary of the Navy shall not contract for the construction or completion of any of said vessels, or of their engines, machinery, or boilers, until drawings and specifications of the same shall have been provided or adopted by him; and after said drawings and specifications shall have been provided, adopted, and approved as aforesaid, and work shall have been commenced on any contract made therefor, such plans and specifications shall not be changed in any respect when the cost of such change in the execution of the work exceeds five hundred dollars, except upon the written order of the Secretary or Acting Secretary of the Navy; and if changes are thus made, the actual cost thereof and the damage caused thereby shall be ascertained, estimated, and determined by a board of naval officers to be provided for in the contract; and in any contract made pursuant to this Act it shall be provided in the terms thereof that the contractor shall be bound by the determination of said board, or a majority thereof, as to the amount of increased or diminished compensation said contractor shall be entitled to receive, if any, in consequence of such change or changes. In every contract to be made under this Act there shall be prescribed a period within which the work provided for in said contract, or specified

portions thereof, shall be completed, and the completion of such work within the periods prescribed shall be insured by penal provisions. For the construction or completion of such vessels hereinbefore provided for as the Secretary of the Navy shall propose to have constructed or completed by contract, as well as also for the engines, boilers, and machinery hereinbefore provided for, he shall invite proposals from every American shipbuilder and other person who shall show to the satisfaction of the Secretary of the Navy, that within three months from the date of the contract he will be possessed of the necessary plant for the performance of the work in the United States which he shall offer to undertake, and such contract shall be let to the lowest and best responsible bidder or bidders, after at least sixty days' advertisement, published in five leading papers of the United States, inviting proposals for the work proposed, which work shall be subject to all such rules, regulations, superintendence by naval officers during construction, and provisions as to bonds and security for the quality and due completion of the work as the Secretary of the Navy shall prescribe; and no vessel, boiler, engine, machinery, or portion thereof shall be accepted unless completed in strict conformity with the contract; and the authority given hereby shall take effect at once. The Secretary of the Navy shall have the power to reject any or all bids made under the provisions of this Act."

1. To carry out the provisions of the Acts referred to, the Department, in advertising for these vessels to be built by contract, will invite proposals for their construction under two classes, viz:

"CLASS 1.—For the construction of the hull and machinery, including engines, boilers, and their appurtenances, and for equipment, complete in all respects, and for the installation of ordnance and ordnance outfit in accordance with the plans and specifications provided by the Secretary of the Navy.

"CLASS 2.—For the construction of the hull and machinery, including engines, boilers, and their appurtenances, and for equipment, complete in all respects, in accordance with plans and specifications submitted by the bidder, and for the installation of ordnance and ordnance outfit in accordance with the requirements of the Department."

2. Proposals under Class 2 will include everything necessary for the construction of the hull and machinery, including engines, boilers, and appurtenances and equipment, complete in all respects (exclusive of armor for hull and gun protection, conning

towers, and communication tubes, which will be furnished by the Government, but must be properly secured in place by the contractors), in accordance with the plans and specifications provided by the bidder. Bidders under Class 2 may, if they so desire, adopt the plans and specifications of the Department for the hull and machinery, or any part of either, and embody them in their plans and specifications to be submitted with their proposals.

3. In order that ample time may be given all ship and marine engine builders who may desire to submit their own plans of the hull and machinery, or of either, this circular defining the general requirements of the vessels and their machinery is issued.

4. Any design of vessel submitted must contain certain customary general requirements usually embodied in specifications prepared by the Department, and must be so drawn as to cover the detailed requirements of the different bureaus of the Department. For further information concerning such detailed requirements application should be made to the respective bureaus concerned.

5. Any design of the vessel submitted must be in such detail and accompanied by such plans, specifications, and calculations as to enable the Department to readily determine its value, and ascertain whether it fulfills the general requirements herein mentioned; the calculations to include complete calculations of weights, displacement, and range of stability under conditions of normal displacement, deep load displacement, and light displacement; such calculations as will determine the extent of injury above and below the armored deck which may be suffered while retaining satisfactory buoyancy and stability, and also such calculations as will demonstrate the satisfactory strength of the whole.

6. The specifications submitted by the bidders under Class 2 must cover fully the ground covered by the Department's specifications. Copies of the Department's specifications will be furnished, in which bidders must show by erasures and additions the exact nature of the hull and machinery, including engines, boilers, and appurtenances complete in all respects that they propose to build. All designs must be accompanied by calculations showing in detail the total weight and position of center of gravity of all machinery.

7. In submitting bids, bidders will be required to specify the time within which they will agree to complete their contracts. No bids will be considered which name a period in excess of thirty-three months for such completion. The following penalties will be imposed for failure to complete the vessels within the limit of

time specified by the bidder, viz: During the six months next succeeding the expiration of said period, $300 a day; and for each and every day during which such completion shall be delayed thereafter, $600, Sundays, in both cases, excepted.

ELEMENTS OF DESIGN.

8. The following general characteristics will be embodied in the Department's design, and their approximate equivalent must be obtained or provided for in all designs submitted:

Length on load water line, normal displacement, feet, .	368
Molded breadth at water line, feet, ...	72
Mean draught at normal displacement, about, feet, . .	23½
Normal displacement, about, tons, ...	11,500
Total coal capacity, loose stowage, tons, ...	1,200

9. The hull is to be of steel, not sheathed, with double bottom and close water-tight subdivision.

10. The arrangement of decks above water is to provide ample free board and berthing accommodations.

11. No sail will be carried, but two military masts are to be fitted with fighting tops.

12. The boats are to be stowed clear of the blast of the guns, and two lifeboats are to be so carried as to be rapidly lowered under all conditions of weather.

13. The protection of the hull against injury to the water-line region is to be afforded by a side armor belt of a maximum thickness of not less than 16½ inches, and a mean depth of 7 feet 6 inches. The belt to extend at least from the stem to the after barbette, and to maintain the maximum thickness through the engine and boiler spaces; from thence forward it may be tapered gradually to a uniform thickness of 4 inches. The transverse armor at the after end of the belt and that just forward of the boiler space will be not less than 12 inches in thickness. Barbettes for 13-inch guns will have armor 15 inches thick, except in the rear, where it will be reduced to 10 inches.

14. The turret armor is to be 14 inches thick throughout. The ship's side, from the armor belt to the main deck, will be protected by not less than 5½ inches of steel armor, from barbette to barbette. Coal is to be carried back of a portion of this 5½-inch casemate armor.

15. A protective deck is to extend throughout the length of the vessel. Where this deck is worked flat, the total thickness will be not less than 2¾ inches; and where worked with inclined sides the slopes will be 3 inches in thickness forward and 5 inches

in thickness aft. A cellulose belt is to be fitted along the sides the whole length of the ship.

16. A conning tower of not less than 10 inches in thickness, having an armored communication tube not less than 7 inches in thickness, will be carried in a suitable commanding position forward, the tube extending to the armor deck and affording protection to the voice tubes, bell wires, etc. An additional armored station will be fitted aft having armor not less than 6 inches in thickness.

17. In wake of the 6-inch guns on the main deck there is to be continuous armor 5½ inches thick extending between the turrets. Further protection is to be afforded by 1½-inch splinter bulkheads between the guns, extending from deck to deck.

18. The 6-inch guns on the upper deck will also be protected by 5½-inch armor, with 1½-inch splinter bulkheads between guns.

19. Protection is to be afforded the smaller guns by shields and extra side plating.

20. In the Department's design the vessel will be driven by twin screws. The engines will be of the vertical, triple-expansion, four-cylinder type, two in number, one on each shaft, to be placed in two separate water-tight compartments. The boilers to be cylindrical, single-ended, eight in number, to be placed in four separate water-tight compartments, to be constructed for a working pressure of 200 pounds.

21. There will be required the usual auxiliary machinery and space for operating the same for use of the engineer's department.

22. The total coal capacity is to be such that at least 1,200 tons can be carried with loose stowage without trimming.

23. The total weight of propelling machinery, including engines, boilers, and appurtenances, all fixtures in engine and fire rooms, smoke pipes, distilling apparatus, stores, spare parts, heating apparatus, tools in workshop, water in boilers, condensers, pumps, pipes, and stern tubes (but not including turret-turning machinery, capstan, windlass, steering gear, or winches) shall not exceed 1,130 tons.

24. The following auxiliary machinery, in addition to that pertaining to the main engines and their dependencies, is to be operated by steam power, viz: Anchor and steering engines, deck and boat winches, ash hoists, blower engines, air compressors, workshop machinery, and all pumps except those worked by hand.

25. Ordnance material will be supplied by the Government and will be installed by the contractors.

26. The battery will be composed of four 13-inch B. L. guns, mounted in two heavily armored barbette turrets on the midship line, one forward and one aft; ten 6-inch rapid-firing guns in broadside on the main deck, and four on the upper deck within the superstructure, and a secondary battery of twenty-four rapid-firing and machine guns.

27. The weight of this battery of guns, with their mounts and carriages will be about 574 tons. The weight of the ammunition required will be about 449 tons, occupying about 16,000 cubic feet stowage space, in addition to the appliances and room for handling it.

28. There will be two submerged torpedo tubes, in a compartment extending a length fore and aft of about twenty feet and having a height of at least six feet. This compartment will be fitted up for the stowage of eight 17-foot torpedoes and appliances and means for handling and operating the same. The total weight of all torpedo installation in this compartment, including tubes, will be about 35 tons. A separate room or magazine will be required for the stowage of torpedo war heads.

29. Underwater torpedo tubes will be supplied by the Government, but the hull connections therefor are to be supplied by the contractors.

30. The complement of officers and crew will be about 500.

31. Provisions and small stores are to be carried for three months. Distilling apparatus and evaporators will be fitted for supplying fresh water. The allowance of water to be carried shall be sufficient for fifteen days, not including necessary water for sanitary purposes. Clothing, contingent, and small stores to be carried in sufficient quantities for the service of the ship for one year.

32. The electric generating plant is to consist of eight units, each unit to have an engine, dynamo, and combination bedplate, and each dynamo a rated output of 400 ampères at 80 volts. The total weight of the eight units complete must not exceed 84,000 pounds. The total weight of the whole electric installation, including dynamos, engines, bedplates, all fittings, wiring, stores, and four search lights, must not exceed 74 tons.

33. The turrets are to have electrical turning gear, to be furnished and installed complete by the contractors. The turret ammunition hoists, elevating gear, and rammers will be supplied by the Government; they are to be operated by electricity, the motors and controlling gear for this purpose to be supplied and installed by the contractors.

34. Ammunition hoists, in addition to those above enumerated,

are also to be operated by electricity; the motors and controlling gear therefor to be supplied and installed by the contractors.

35. Electric power shall be employed for operating all turrets, ammunition hoists, for working the guns, for ventilating fans below the armored deck and for small ventilating fans above.

36. SUMMARY OF PRINCIPAL WEIGHTS.

	Tons.
Guns and mounts,	574
Ammunition, ordnance stores and submerged torpedo outfit,	484
Machinery, complete,	1,130
Equipment, complete,	199
Turret turning machinery,	90
Boats and outfit,	24
Masts and spars,	29
Officers, crew, provisions and clothing,	144
Miscellaneous stores and water,	81

37. Two-thirds of total coal, plus two-thirds of full ammunition, plus two-thirds of total stores, must be carried at the normal displacement of 11,500 tons.

38. If on trial the average speed shall equal or exceed a speed at sea of 16 knots an hour for four consecutive hours, the vessel will be accepted so far as the speed is concerned. If the speed falls below 16 knots and exceeds 15 knots an hour, the vessel will be accepted at a reduced price, the reduction being at the rate of $25,000 a quarter knot deficiency of speed from 16 knots to 15½ knots, and at the rate of $50,000 a quarter knot deficiency of speed from 15½ knots to 15 knots. If the speed falls below 15 knots an hour, the vessel may, in the discretion of the Secretary of the Navy, be rejected, or accepted at a reduced price to be agreed upon between the Secretary and the contractors. In case of rejection, any money that may have been paid to the contractors on account shall be refunded.

The speed proposed for these battleships was modified by the Navy Department in a notice to shipbuilders dated July 26, as follows:

The Department will, in awarding contracts for the construction of battleships Nos. 10, 11 and 12, under its advertisement of June 7, give preference, other things being equal, to such bids as offer

to guarantee the highest rate of speed and greatest coal endurance, the total weights of engines, boilers and coal, and the spaces allowed therefor, to remain as now fixed by the circular defining the chief characteristics of said vessels, and the Department plans and specifications, and the vessels to have a steaming radius of not less than 5,432 knots at a speed of 10 knots per hour.

In explanation of this change, it may be said that it had been decided, when the circular was issued, for various reasons, to make these new ships practically duplicates of the *Alabama* class. Afterwards the Department, in view of the fact that practically all other nations are designing battleships for a speed of 18 knots or higher, sent out this supplementary notice to probable bidders, in order that in the alternative designs provided for under Class 2, they might propose higher speeds if they saw fit.

The Board on Construction also took up the subject again, and the Engineer-in-chief submitted a number of preliminary designs, of which about six were for speeds of 17.4 knots or higher, several being for 18 knots. Several of these involved the use of water-tube boilers which would have caused a material change of trim and thus have necessitated a recasting of the hull design.

Two, however, were based on the use of cylindrical boilers with heated ash-pit draft, and did not involve a change of trim. The increased space and weight for machinery involved, of course, a decrease in the amount of coal carried, but it was expected, on account of the increased economy of both engines and boilers, to secure an increased radius of action at the standard speed of 10 knots. As the working out of these plans in detail would have involved a delay of some weeks in making the contracts, and as the Board found the plans not entirely unobjectionable, it was decided not to make any change in the Department's design until it is ascertained whether the builders will offer alternative designs guaranteeing higher speeds.

It is easy to understand that, when an attempt is made to put in machinery for about 14,500 I.H.P. in a ship planned for only 10,000 I.H.P., getting the space and weight needed by reducing the amount of coal carried, the result is one which, while solving

the problem, may not commend itself from every point of view to those who are considering the question from the standpoint of the general efficiency of the ship as a whole. All experts do not agree with Mr. Laird Clowes that speed should be the ruling factor.

It is understood that some of the builders have intimated that they propose to submit designs for higher speeds than 16 knots, and in the bids of Class 2, the bidder has complete latitude and is not compelled to get a high speed out of a ship designed originally for a lower one.

As the Navy Department is determined to have ships that are equal to the best in the world in every respect, it is probable that, if no alternative designs are offered for higher speeds, the Department will prepare a new design.

The following abstract gives some of the principal points in the design of machinery prepared by the Bureau of Steam Engineering for the 16-knot battleships.

The propelling engines will be rights and lefts, placed in water-tight compartments and separated by a middle-line bulkhead. These engines will be of the vertical, inverted-cylinder, direct-acting, triple-expansion type, each with a high-pressure cylinder 30 inches, an intermediate-pressure cylinder 46½ inches, and two low-pressure cylinders 53 inches in diameter—the stroke of all pistons will be 48 inches. The collective indicated horsepower of propelling, air-pump, and circulating-pump engines will be 10,000 when the main engines are making about 120 revolutions per minute.

The high-pressure cylinder of each engine will be forward and the intermediate-pressure cylinder aft, the low-pressure cylinders being between these two. The main valves will be worked by Stephenson link motions with double-bar links. The valve gear of the four cylinders will be made interchangeable so far as is practicable. There will be one piston valve for each high-pressure cylinder and two for each intermediate-pressure cylinder; each low-pressure cylinder will have a double-ported slide valve. Each main piston will have one piston rod, with a crosshead working on a slipper guide.

The framing of the engines will consist of wrought-steel

columns trussed by wrought-steel stays. The engine bedplates will be of cast steel, supported on the keelson plates. The crank shafts will be made in four sections, the first and fourth and the second and third being made interchangeable.

The sequence of cylinders, beginning from forward, will be: High pressure, first low pressure, second low pressure, and intermediate pressure. The high and first low-pressure cranks will be opposite, also the intermediate and second low, the second pair being at right angles with the first. The sequence of cranks will then be: High pressure, intermediate, first low, and second low pressure. The Bureau of Steam Engineering will take into consideration any system of balancing that the contractors may wish to propose. All crank, line, and propeller shafting will be hollow. The shafts, piston rods, connecting rods, and working parts generally will be forged of open-hearth steel.

The condensers will be made of composition and wrought steel. Each main condenser will have a cooling surface of about 6,750 square feet, measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be a double, vertical, single-acting air pump worked by two inverted steam cylinders. The main circulating pumps will be of the centrifugal type, one for each condenser, worked independently. The propellers will be right and left, of manganese bronze or approved equivalent metal.

Each engine room will have an auxiliary condenser, made of composition, having not less than 800 square feet of cooling surface, measured on the outside of tubes. Each condenser will be connected with all the auxiliary machinery. Each of these condensers will have a combined air and circulating pump.

There will be eight single-ended steel boilers of the horizontal-return fire-tube type, constructed for a working pressure of 200 pounds per square inch. The boilers will be placed in four water-tight compartments, as shown on the drawings. There will be one fire room in each of the main boiler compartments.

The total heating surface of all of the boilers, measured on the outside of the tubes, will be about 21,014 square feet, and the total grate surface will be about 685 square feet.

Each of the boilers will have four corrugated furnace flues of 39 inches internal diameter.

All the boilers will have an outside diameter of about 15 feet 8 inches, and a length of about 9 feet 11¼ inches.

There will be two main feed pumps, placed in each engine room.

There will be placed in each fire room one approved auxiliary

feed pump. There will be, in addition to these pumps, approved fire, bilge, water service, and other pumps, to be located as described in the detailed specifications. There will be two smoke pipes.

The forced-draft system will consist of two blowers for each fire room, the blowers discharging into an air-tight fire room.

There will be steam reversing gear, ash hoists, turning engines, auxiliary pumps, engine for workshop machinery, a distilling and evaporating apparatus, and the other usual auxiliary machinery, tools, and instruments.

The high-pressure cylinders will be steam-jacketed around the working linings and the intermediate-pressure and low-pressure cylinders will be steam-jacketed around the working linings and at both ends.

The thrust bearings will be of the horseshoe pattern, and the stern-tube and stern-bracket bearings will be fitted with lignum vitae in the usual way.

The condenser shells will be of wrought steel $\frac{5}{16}$ inch thick, properly stiffened by angles. The other parts and mountings will, as usual, be of composition.

All copper suction and discharge pipes, designed to convey salt water, will be fitted at intervals of from 10 to 15 feet with cast composition boxes, with flanges matching flanges on pipes. These boxes will be placed on horizontal sections of pipe. The bottom of the boxes will have a faced opening and a bonnet. A rolled zinc slab will be secured to the bonnet by at least two naval-brass bolts tapped through the bonnet, with heads outside, the zinc being secured by nuts. The zinc protecting rings in the sea-suction valves will be regarded as one of the zinc boxes in spacing the remainder. Each pump discharge pipe, designed to convey salt water, will have a zinc box as near the pump as is practicable, after which they will be spaced as specified. The design of the boxes must be such as to leave the pipe unobstructed.

Provision is made for taking in fresh water for boilers by suctions leading from the hot well pumps to nozzles on the ship's side above water.

There will be two smoke pipes, each about 93 feet above the base line, or about 87 feet above lower grates.

There will be provided the following tools, arranged to work by hand and power; to be of the best make and to be approved by the Bureau of Steam Engineering:

1. A back-geared screw-cutting engine lathe; to swing 24 inches over ways and 16½ inches over carriage and take 4 feet

between centers. It will be fitted with gear for cutting threads from 2 to 32 to the inch, and with four-grade cone-pulleys.

It will have a hollow spindle on the driving head, with hole $1\frac{1}{2}$ inches diameter. The carriage will have automatic cross feed. The lathe to be fitted with scroll and drill chucks. Weight not to exceed 4,000 pounds. Bed not to exceed 8 feet in length.

2. A 14-inch, back-geared, screw-cutting engine lathe; to swing 14 inches over bed, 9 inches over carriage, and take 10 inches between centers. To have hollow spindles with $\frac{3}{4}$-inch holes on driving head, and be fitted with gears to cut from 4 to 64 threads per inch; lead screws to be used for screw cutting only. Lathe to have taper cutting attachment and to be fitted with scroll and drill chucks. Cone-pulley to have four steps. Length of bed not to exceed 6 feet.

3. A column-shaping machine, of 15 inches stroke and 24 inches traverse, with vertical adjustment to table and arbor for circular planing; to have four-grade cone-pulleys, and be fitted with chuck. Weight not to exceed 2,200 pounds.

4. A double-geared drilling machine with screw feed; to have three-grade cone-pulleys, and be capable of drilling from $\frac{1}{2}$ to $1\frac{1}{2}$-inch holes; to have adjustable swinging table; to drill 18 inches from edge of work.

5. A small iron column bench drilling machine for hand and power, to have three-grade cone pulleys; to drill from $\frac{1}{8}$ to $\frac{3}{4}$-inch holes; to have automatic feed.

6. A combined hand punch and shears, capable of cutting $\frac{3}{4}$ inch round iron, shearing $\frac{3}{8}$-inch steel plate, and punching $\frac{3}{8}$-inch holes in $\frac{3}{8}$-inch mild steel plate; shear blades to be 6 inches in length.

One emery grinder with two wheels 12 inches in diameter and 2-inch face.

A vertical engine will be provided to drive these tools; engine will have fly wheel, driving pulley, and automatic governor; to make about 160 revolutions per minute.

The tools above specified will be erected and fitted where directed in the engineer's workshop. Each machine will be driven from a countershaft with cone pulleys to suit the machine.

Countershafts, hangers, and pulleys will be provided for each of the above tools.

The distilling apparatus will consist of two evaporators and two distillers, with their accessories, having a combined capacity of 8,000 gallons of potable water per 24 hours at a temperature of not more than 90° Fahrenheit. Each evaporator will have at least 200 square feet of tube heating surface. Each distiller will have at least 132 square feet of tube cooling surface. The

evaporators will be of the type adopted by the Bureau of Steam Engineering.

There will be an approved ice machine of the "dense-air" type, capable of producing the cooling effect of one ton of ice per day. It will have cooling pipes, as directed, to the ice tank, to the cold storage or refrigerating room, and to the scuttle butt.

The main and auxiliary steam pipes will generally be of mild steel, lap-welded. An ingenious method of simplifying the piping and avoiding large sizes has been arranged as follows:

A 6-inch pipe, with ample bends to provide for expansion, will lead from the main stop valve on each boiler through stuffing boxes at the athwart-ship bulkhead dividing the fire rooms, and at the bulkhead at after end of after fire rooms, to a manifold at the forward bulkhead in each engine room. The manifolds will be steel castings, forming the upper part of the main separators, and the main steam pipe from each boiler will communicate with the manifold through angle stop valves.

Each separator will have two nozzles, the outboard one 12 inches and the inboard one 10½ inches in diameter. To the outboard nozzle will be bolted a composition elbow, tapering to 10½ inches diameter of bore where it joins the main stop valve in each engine room. It will contain a 6-inch nozzle for connecting with the auxiliary steam pipe, and a 5-inch nozzle for bleeder connection. From the main stop valve in each engine room a 10½-inch banded copper pipe or a steel pipe will connect with the engine throttle valve. Between the inboard nozzles on the separators there will be a cross-connecting pipe with a stop valve, worked from both engine rooms, at the middle-line bulkhead. The cross-connecting pipe will be a 10½-inch steel pipe.

The pipes connecting the main and auxiliary steam pipes in engine rooms will have a valve both at the main and at the auxiliary steam pipes. These connecting pipes will have branches, with stop valves, for taking steam from the main steam pipe to the main air, circulating, and feed pumps, and the hot-well pumps.

The 10½-inch stop valves in engine rooms will be fitted with by-pass valves.

Copper main steam pipes will be banded wherever their diameter exceeds 9 inches. The bands will be of forged steel 2 inches wide by ⅛ inch thick, spaced 6 inches between centers. The bands will be of approved design, and will be provided with tension screws or keys. Suitable and approved means must be provided by taking up expansion in the steam pipes.

There will be a 6-inch stop valve on each boiler, with horizontal spindle, and pipes will be fitted connecting the dynamo engines with the boilers. There will be no connection between the auxiliary and the dynamo steam pipes. The lead will be as direct as possible to separators placed near the dynamo engines or groups of dynamo engines. Valves will be placed in the pipes leading from the separators to each engine, so that the steam may be shut off from the pipes when the engine is not in use. The traps for the separators must be of the proper size, and will be fitted with by-pass pipes and valves, so that they may be cleaned without shutting steam off from the engines. There will be approved reducing valves in the dynamo-engine steam pipes, placed near the separators.

The drainpipes must be so fitted that it will be impossible for one dynamo engine to blow into another, or for one end of one cylinder to blow into the other end of the same cylinder.

Swing checks will be fitted in all drainpipes close to the cylinder or chest from which they lead, and the drainpipes will be joined by a approved Y or T. The drainpipes from the cylinders must not lead to a trap.

The dynamo-engine exhaust pipes must be so led and joined by approved Y's or T's that one engine cannot exhaust against another, or the unused engine be flooded, and swing check valves will be fitted in all exhaust pipes close to the valve chests.

Care will be taken to prevent the flooding of exhaust branches from dynamo engines, or groups of dynamo engines, on a level lower than that of the auxiliary exhaust main, by water from the latter, and separators, with approved traps and pumps, will be fitted where directed, to guard against this contingency.

The dynamo-engine exhaust will be so arranged, by means of pipe connections, and valves operated from the dynamo compartment, that it may be turned into the atmosphere, through the escape pipes, independently of the auxiliary exhaust. The connection with the escape pipes will be fitted with two valves to guard against air leaks.

There will be in each engine room an approved feed-water heater, which will contain about 500 square feet of tube heating surface. Approved provision must be made to prevent crawling of tubes due to unequal expansion of tubes and shell. Each heater will be fitted with a combined vacuum and pressure gauge connected with the steam space. Each feed heater will be fitted with an approved trap of ample size, with by-pass pipes and valves, for convenience in overhauling. A pump of approved capacity and type will draw from each trap and discharge to the feed tanks.

The safety valves, boiler stop valves, and main stop valves in engine rooms, between manifold and engine throttle valves, will have suitable gear for working them from the berth deck.

Monitors 7, 8, 9 and 10, Arkansas, Connecticut, Florida and Wyoming.

The following extracts are from the circular issued by the Navy Department. The parts quoting the acts of Congress and the general instructions are in the main the same as for the battleships, but no alternative designs are invited.

"That for the purpose of further increasing the naval establishment of the United States the President is hereby authorized to have constructed by contract four harbor-defense vessels of the monitor type, each having one or two turrets, and to cost, exclusive of armament, not exceeding one million two hundred and fifty thousand dollars each. And not more than two of said harbor-defense vessels shall be built in one yard or by one contracting party, and the contracts for the construction of each of said vessels shall be awarded by the Secretary of the Navy to the lowest best responsible bidder, having in view the best results and most expeditious delivery; and in the construction of all said vessels all of the provisions of the Act of August third, eighteen hundred and eighty-six, entitled 'An Act to increase the naval establishment,' and amendments subsequently made thereto as to materials for said vessels, their engines, boilers, and machinery, the contracts under which they are built, except as to premiums, which are not to be offered, the notice of any proposals for the same, the plans, drawings, and specifications, therefor, and the method of executing said contracts, shall be observed and followed, and said vessels shall be built in compliance with the terms of said Act, save that in all their parts said vessels shall be of domestic manufacture; and subject to the provisions hereinafter made. And one and not more than one of the aforesaid harbor-defense vessels shall be built on or near the coast of the Pacific Ocean or in the waters connecting therewith: *Provided*, That if it shall appear to the satisfaction of the President of the United States, from the biddings for such contracts when the same are opened and examined by him, said vessel can not be constructed on or near the coast of the Pacific Ocean at a cost not exceeding four per centum above the lowest accepted bid for the other harbor-defense vessels provided for in this Act, he shall authorize the construction of said vessel elsewhere in the United

States, subject to the limitations as to cost hereinbefore provided."

1. In the Act of Congress making appropriations for the naval service for the fiscal year ending June 30, 1899, approved May 4, 1898, provision is made, under "Increase of the Navy," for four harbor-defense vessels of the monitor type, to cost, exclusive of armament, not more than $1,250,000 each.

2. To carry out the provisions of the Act of May 4, 1898, the Department, in advertising for these vessels to be built by contract, will invite proposals—

"For the construction of the hull and machinery of each of said vessels, including engines, boilers, and their appurtenances, and for equipment, complete in all respects, and for the installation of ordnance and ordnance outfit, in accordance with the plans and specifications provided by the Secretary of the Navy."

3. Proposals will include everything necessary for the construction of the hull and machinery, including engines, boilers, and their appurtenances and equipment, complete in all respects (exclusive of armor for hull and gun protection, conning tower, and communication tube, which will be furnished by the Government, but must be properly secured in place by the contractors), in accordance with the plans and specifications provided by the Department.

4. The bids submitted must be under the Department's design and specifications as stated above, and must be so drawn as to cover all of the detailed requirements, called for therein, of the different Bureaus of the Department. For further information concerning such detailed requirements, applications should be made to the respective Bureaus concerned.

5. In inviting bids, the Department will require that each bid state the time within which the contract for each of said vessels will be completed. No bid will be considered which names a time greater than twenty-seven months for such completion. The following penalties will be imposed for failure to complete the vessels within the limit of time specified by the bidder, viz: During the six months next succeeding the expiration of said period, $300 a day; and for each and every day during which such completion shall be delayed thereafter, $600, Sundays in both cases excepted.

ELEMENTS OF DESIGN.

6. The following will be the general characteristics of these vessels:

Length on load water line (normal displacement), feet,	225
Breadth, extreme, at water line, feet,	50
Mean draught at normal displacement, about, feet,	12½
Normal displacement, about, tons,	2,700
Total coal capacity, loose stowage, tons,	200

7. The hull is to be of steel, not sheathed, with double bottom, and close water-tight subdivisions.

8. One military mast is to be fitted with fighting and search-light tops.

9. The boats are to be stowed clear of the blast of the guns, and two lifeboats are to be so carried as to be quickly lowered.

10. The protection of the hull against injury to the water-line region is to be afforded by means of a side-armor belt of a maximum thickness of not less than 11 inches, and a mean depth of 5 feet. The belt to extend throughout the length of the vessel, and to maintain the maximum thickness abreast the engine and boiler spaces; from thence forward and aft it may be tapered gradually to a uniform thickness of 5 inches. The barbettes for the 12-inch guns will have armor 11 inches thick.

11. Turrets to be of the balanced type, with front plate inclined 42 degrees from the vertical. The turret armor is to be 10 inches thick.

12. A protective deck is to extend throughout the length of the vessel, to be worked flat. The total thickness will be not less than 1½ inches.

13. A conning tower of not less than 7½ inches in thickness, having an armored communication tube not less than 3 inches in thickness, will be carried in a suitable commanding position forward, the tube extending to the armor deck and affording protection to the voice tubes, bell wires, etc.

14. The vessel will be driven by twin screws. The engines (two in number) are to be of the vertical triple-expansion type, in one water-tight compartment. The boilers (four in number) are to be of the water-tube type, constructed for a working pressure of 250 pounds, and are to be placed in one water-tight compartment.

15. There will be required the usual auxiliary machinery and work-shop tools, and space for operating the same, for use of Engineer's Department. Distilling apparatus and evaporators will be fitted for supplying fresh water.

16. The total coal-bunker capacity is to be such that at least 200 tons can be carried with loose stowage without trimming.

17. The total weight of propelling machinery, including en-

gines, boilers and their appurtenances, all fixtures in engine and fire rooms, smoke pipes, distilling apparatus, stores, spare parts, heating apparatus, tools in workshop, water in boilers, condensers, pumps, pipes, and stern tubes (but not including turret-turning machinery, capstan, windlass, steering gear, or winches), shall not exceed 240 tons. In addition, tankage for 50 tons of water for steaming purposes must be supplied.

18. The following auxiliary machinery, in addition to that pertaining to the main engines and their dependencies, is to be operated by steam power, viz: anchor and steering engines, deck and boat winches, ash hoists, blower engines, workshop machinery, and all pumps except those worked by hand.

19. Ordnance material will be supplied by the Government, and will be installed by the contractors.

20. The battery will be composed of two 12-inch B. L. guns, mounted in an armored barbette turret on the midship line forward; four 4-inch R. F. guns in broadside on the superstructure deck; and a secondary battery of seven R. F. guns.

21. The weight of this battery of guns, with their mounts and carriages, will be about 177 tons. The weight of the ammunition required will be about 93 tons, occupying about 3,300 cubic feet contents, in addition to the appliances and room for handling and stowing it.

22. The complement of officers and crew will be about 130.

23. Provisions and small stores are to be carried for one month. The allowance of fresh water to be carried shall be sufficient for five days. Clothing, contingent, and small stores to be carried in sufficient quantities for the service of the ship for three months.

24. The electric generating plant is to consist of four units, each unit to have an engine, dynamo, and combination bedplate, and each dynamo a rated output of 400 ampères at 80 volts. The total weight of the four units complete must not exceed 40,000 pounds. The total weight of the whole electric installation, including dynamos, engines, bedplates, all fittings, wiring, stores, and two search lights, must not exceed 32 tons.

25. The turrets are to have electrical turning gear, to be furnished and installed complete by the contractors. The turret ammunition hoists, elevating gear, and rammers will be supplied by the Government. They are to be operated by electricity; the motors and controlling gear for this purpose to be supplied and installed by the contractors.

26. Ammunition hoists, in addition to those above enumerated, are also to be operated by electricity; the motors and controlling gear therefor to be supplied and installed by the contractors.

27. SUMMARY OF PRINCIPAL WEIGHTS.

	Tons.
Guns and mounts,	177
Ammunition and ordnance stores,	95
Machinery, complete,	240
Water for steaming purposes,	50
Equipment, complete,	75
Boats and outfit,	9
Officers, crew, and effects,	13
Miscellaneous stores and potable water,	22

28. Two-thirds of the ammunition and stores, 10 tons of water for steaming purposes, and 200 tons of coal must be carried at the normal displacement.

29. If, on trial, the average speed shall equal or exceed a speed at sea of 12 knots an hour for two consecutive hours, the vessel will be accepted so far as the speed is concerned. If the speed falls below 12 knots and exceeds 11 knots an hour the vessel will be accepted at a reduced price, the reduction being at the rate of $5,000 a quarter knot deficiency of speed from 12 knots to 11½ knots, and at the rate of $10,000 a quarter knot deficiency of speed from 11½ knots to 11 knots. If the speed falls below 11 knots an hour the vessel may, in the discretion of the Secretary of the Navy, be rejected, or accepted at a reduced price to be agreed upon between the Secretary and the contractors. In case of rejection, any money that may have been paid to the contractors on account shall be refunded.

The propelling machinery will consist of twin-screw, vertical, triple-expansion engines of 2,400 I.H.P. The cylinders are 17 inches, 26¼ inches and 40 inches diameter, by 24-inch stroke, working at 200 revolutions and 200 pounds steam pressure. There will be a condenser for each engine with 1,620 square feet of cooling surface. There will be four water-tube boilers with an aggregate grate surface of about 200 square feet, and heating surface of about 8,800 square feet. The forced draft will be by closed fire rooms. The working pressure will be 250 pounds, reduced to 200 at the engines. The general details of the specifications are similar to those for the battleships.

Torpedo-Boat Destroyers 1 to 16, and Torpedo Boats 24 to 35, named as follows:

Torpedo-Boat Destroyers—No. 1, *Bainbridge;* No. 2, *Barry;*

No. 3, *Chauncey;* No. 4, *Dale;* No. 5, *Decatur;* No. 6, *Hopkins;* No. 7, *Hull;* No. 8, *Lawrence;* No. 9, *Macdonough;* No. 10, *Paul Jones;* No. 11, *Perry;* No. 12, *Preble;* No. 13, *Stewart;* No. 14, *Truxton;* No. 15, *Whipple;* No. 16, *Worden.* Torpedo Boats—No. 24, *Bagley;* No. 25, *Barney;* No. 26, *Biddle;* No. 27, *Blakely;* No. 28, *De Long;* No. 29, *Nicholson;* No. 30, *O'Brien;* No. 31, *Shubrick;* No. 32, *Stockton;* No. 33, *Thornton;* No. 34, *Tingey;* No. 35, *Wilkes.*

The following data are from the circular issued by the Navy Department. The extracts from acts of Congress and the general instructions are, in the main, the same as for the battleships. Bids are invited under two classes as for them.

"That for the purpose of further increasing the naval establishment of the United States, the President is hereby authorized to have constructed by contracts . . . sixteen torpedo-boat destroyers of about four hundred tons displacement, and twelve torpedo boats of about one hundred and fifty tons displacement, to have the highest practicable speed, and to cost in all, exclusive of armament, not exceeding six million nine hundred thousand dollars; . . . *Provided,* That . . . not more than five of said torpedo-boat destroyers and not more than four of said torpedo boats shall be built in one yard or by one contracting party, and the contract for the construction of each of said vessels shall be awarded by the Secretary of the Navy to the lowest best responsible bidder, having in view the best results and most expeditious delivery; and in the construction of all said vessels all of the provisions of the Act of August third, eighteen hundred and eighty-six, entitled 'An Act to increase the naval establishment,' and amendments subsequently made thereto as to materials for said vessels, their engines, boilers, and machinery, the contracts under which they are built, except as to premiums, which are not to be offered, the notice of any proposals for the same, the plans, drawings, and specifications therefor, and the method of executing said contracts shall be observed and followed, and said vessels shall be built in compliance with the terms of said Act, save that in all their parts said vessels shall be of domestic manufacture, except that no proposals for the torpedo vessels shall be considered unless the bidder is already in possession of adequate plant, and that the advertisement relating to the proposals for such vessels may be published for three weeks only." . . .

To carry out the provisions of the Act referred to, approved

Name.	Date.	Length.	Beam.	Draught.	Displacement.	Armament.	Torpedo tubes.
		ft. *ins.*	*ft* *ins.*	*ft.* *ins.*	*tons.*		
Cushing	1890	137 6	14 3	4 10½	105.3	3 1-pdrs.	1 bow, 2 deck. 18″
Ericsson	1891	150 0	15 6	4 9	120	4 1-pdrs.	1 18-in bow, 2 on deck.
Foote, Rodgers, Winslow,	1895	160 0	16 0	5 0	143.9	3 1-pdrs.	3 18-inch.
Porter, Dupont,	1895	175 6	17 6	6 9	165 ...	3 1-pdrs.	3 18 inch.
Rowan	1895	170 0	17 0	5 6	184	4 1-pdrs.	3 18 inch.
T. A. M. Craven, Dahlgren,	1896	147 0	16 4½	4 7½	143.3	4 1-pdrs.	3 18-inch.
Farragut	1896	210 0	20 0	6 0	240	6 6-pdrs.	2 18-inch.
Davis, Fox,	1896	146 0	14 6	5 2	110.4	3 1-pdrs.	3 18 inch.
Morris	1896	139 0	15 0	4 3	98	3 1-pdrs.	3 18-inch.
Talbot, Gwin,	1896	100 0	12 0	3 9⅜ / 3 9⅛	45.75 / 44.5	1 1-pdr.	2 18-inch.
Mackenzie	1896	101 6	12 6	4 3	65	1 1-pdr.	2 18-inch.
McKee	1896	101 6	12 6	4 8⅜	65	1 1-pdr.	2 18-inch.
Stringham	1897	225 0	21 3½	6 6	340	7 6-pdrs.	2 18-inch.
Goldsborough	1897	191 8	20 2	5 0	247.5	4 6 pdrs.	2 18-inch.
Bailey	1897	205 0	18 3	6 0	235	4 6-pdrs.	2 18-inch.
Torpedo Boats, Nos. 24 to 35	1898	175 0	17 0	4 8	165	3 3-pdrs.	3 18-inch.
T. B. Destroyers, Nos. 1 to 16	1898	245 0	23 0	6 6	420	2 12 pdrs. 5 6-pdrs.	2 18 inch.

DIMENSIONS AND OTHER DATA FROM TORPEDO BOATS AND D

Compiled by Assistant Constructor H. G. Gillm

Designed speed.	Trial speed.	Designed I.H.P.	Weight of hull.	Weight of propelling machinery.	Trial load.	Bunker capacity.	Diameter of cylinders.			Stroke.	Revolutions.
							H.P.	I.P.	L.P.		
knots.	*knots.*		*tons.*	*tons.*	*tons.*	*tons.*	*inches.*	*inches.*	*inches.*	*inches.*	
22	22.53	1,750	33.7	54.5	17.3	39	$11\frac{1}{4}$[b]	$\left\{\begin{matrix}16\\22\frac{1}{2}\end{matrix}\right\}$	$22\frac{1}{2}$[b]	15	375
24	...	1,800	49.20	58.46	17.5	35	$11\frac{1}{2}$[b]	$\left\{\begin{matrix}16\\21\frac{1}{2}\end{matrix}\right\}$	30	16	385
$24\frac{1}{2}$	$\left\{\begin{matrix}24.57\\...\\24.54\end{matrix}\right\}$	2,000	93.1	50.82	30.5	44	12	$19\frac{1}{4}$	22	16	395.7
$27\frac{1}{2}$	$\left\{\begin{matrix}28.62\\28.58\end{matrix}\right\}$	3,400	56.5	76.8	29.5	60	16	22	25[b]	16	$\left\{\begin{matrix}389\\396\end{matrix}\right\}$
26	...	3,200	65[a]	92.0[a]	27.32	60	$14\frac{1}{2}$	23	$25\frac{3}{4}$[b]	18	395
30	...	4,200	44.55[a]	78.20[a]	20.29	32	$17\frac{1}{2}$	$24\frac{3}{4}$	37	21	340
30	...	5,600	85[a]	120[a]	35	80	20	29	30[a]	18	400
$22\frac{1}{2}$	...	1,750	42.6[a]	57.1[a]	20.0	40	$11\frac{7}{8}$	19	$22\frac{7}{8}$[b]	15	395
$22\frac{1}{2}$	24.0	1,750	35.9	40.5	20	28	$12\frac{1}{2}$	18	25	$13\frac{1}{2}$	452
20	$\left\{\begin{matrix}21.15\\20.88\end{matrix}\right\}$	850	16.5	19.3	10.5	8	$12\frac{1}{2}$	18	25	$13\frac{1}{2}$	$\left\{\begin{matrix}439\\444\end{matrix}\right\}$
20	...	850	...	...	...	...	12	$19\frac{1}{2}$	22[b]	16	350
20	19.82	850	26.30	22.09	13.90	...	12	$19\frac{1}{4}$	22[b]	16	307
30	...	7,000	130[a]	163[a]	60	100	$21\frac{1}{2}$	$32\frac{1}{2}$	34[b]	18	400
30	...	6,000	83.8[a]	124.6[a]	41.6	131	$19\frac{1}{2}$	$31\frac{3}{4}$	35[b]	18	360
30	...	5,600	67.5[a]	125.00[a]	41.5	...	20	29	30[b]	18	400
26	...	3,000	67.0	79.74	27	70	14	22	$25\frac{1}{4}$[b]	18	350
28	...	8,000	181.0	189.07	52	212	$20\frac{1}{2}$	32	38[b]	22	327

a. Estimated. *b.* Quadruple expansion. *c.* Outside. *d.* Exclusive of water. *e.* Projected. *f.* Helico

FROM TORPEDO BOATS AND DESTROYERS OF THE UNITED STATES.

BY ASSISTANT CONSTRUCTOR H. G. GILLMOR, U. S. NAVY.

Diameter of cylinders.			Stroke.	Revolutions.	Number of boilers.	Kind of boilers.	Grate surface, each boiler.	Heating surface.	Boiler pressure.	Weight of engine, condenser, etc.	Weight of boiler, water and fittings.
H.P.	I.P.	L.P.									
inches.	*inches.*	*inches.*	*inches.*				*sq. ft.*	*sq. ft.*	*pounds.*	*tons.*	*tons.*
$11\frac{1}{4}$[b]	$\left\{\begin{matrix}16\\22\frac{1}{2}\end{matrix}\right\}$	$22\frac{1}{2}$[n]	15	375	2	Thornycroft.	38.65	2,252	235	34.0	20.50
$11\frac{1}{2}$[b]	$\left\{\begin{matrix}16\\21\frac{1}{2}\end{matrix}\right\}$	30	16	385	2	Thornycroft.	42.5	2,349	250	27.96	29.14
12	$19\frac{1}{4}$	22	16	395.7	2	Mosher.	45.5	2,630	$240\frac{1}{2}$	$\left\{\begin{matrix}31.62\\42.50\end{matrix}\right\}$	$\left\{\begin{matrix}19.20\\34.30\end{matrix}\right\}$
16	22	25[n]	16	$\left\{\begin{matrix}389\\396\end{matrix}\right\}$	3	Du Temple.	53.5	2,710	214	...	...
$14\frac{1}{2}$	23	$25\frac{3}{4}$[n]	18	395	3	Mosher.	47	2,630	250	56.5[a]	35.50[a]
$17\frac{1}{4}$	$24\frac{3}{4}$	37	21	340	2	Normand.	55	$\left\{\begin{matrix}2,580\\3,400\end{matrix}\right\}$	230	47.55[a]	30.65[a]
20	29	30[n]	18	400	3	Thornycroft.	66	4,000[c]	240	63.51[a]	56.49[a]
$11\frac{7}{8}$	19	$22\frac{7}{8}$[n]	15	395	2	Thornycroft.	74	2,426	250	30.22[a]	26.78[a]
$12\frac{1}{2}$	18	25	$13\frac{1}{2}$	452	2	Du Temple.	40	1,932	225	18.4	13.7[d]
$12\frac{1}{2}$	18	25	$13\frac{1}{2}$	$\left\{\begin{matrix}439\\444\end{matrix}\right\}$	1	Du Temple.	38	1,850	225	9.3	6.4[d]
12	$19\frac{1}{2}$	22[n]	16	350	2	Thornycroft.	40	2,168	250	...	...
12	$19\frac{1}{4}$	22[n]	16	307	...	Mosher.	40	2,120	260	...	...
$21\frac{1}{2}$	$32\frac{1}{2}$	34[n]	18	400	4	Thornycroft.	63	4,004	240	78.0	85.0
$19\frac{1}{2}$	$31\frac{3}{4}$	35[n]	18	360	3	Thornycroft.	67.2	4,420	250	67.0[a]	57.6[a]
20	29	30[n]	18	400	4	Seabury.	59	3,000	245	...	...
14	22	$25\frac{1}{2}$[n]	18	350	3	Water tube.	137	7,544	250	35.99	43.75
$20\frac{1}{2}$	32	38[n]	22	327	4	Water tube.	315	17,768	300	90.81	98.26

f. Exclusive of water. *e*. Projected. *f*. Helicoidal. *g*. Developed. *n*. Two L.P. cylinders of this size to eac

	Number of screws.	Number of blades.	Pitch.	Diameter.	Blade area.	Slip per cent.	Piston speed, feet per minute.	Remarks.	Builders.
			ft. *ins.*	*ft.* *ins.*	*square feet.*				
o	2	4	8 5	4 3	9.3, 6.12[a]	27	935	.....	Herreshoff Mfg. Co.
4	2	...	7 8	4 9	8.5[f]	...	1,026	.....	Dubuque Iron Works.
o } o }	2	3	7 10	5 2	9.68[f]	19.81	1,056	.....	Columbian Iron Works.
	2	3	9 0	5 4	7.1[e]	17.16 18.74	1,037 1,056	.....	Herreshoff Mfg. Co.
o[n]	2	4	8 8	6 0	11.32[f]	...	1,185	Not yet completed. Elements given are as designed.	Moran Bros.
5[n]	2	3	10 8	6 4	.....	...	1,190	do.	Bath Iron Works.
9[e]	2	3	8 9	6 9	9, 6.4[e]	...	1,200	do.	Union Iron Works.
8[n]	2	3	7 3	4 10½	8.5[g]	...	987	do.	Wolff & Zwicker.
[i]	2	3	6 3	4 8	.....	13.88	1,017	Weights, boilers and fittings without water.	Herreshoff Mfg. Co.
[i]	1	3	6 3	4 6	.....	21.86 23.74	988 999	do.	Herreshoff Mfg. Co.
	1	4	6 7	5 3	11[g]	...	933	.....	Hillman & Sons.
	1	3	7 9½	5 3	9.7[g]	...	818	.....	Columbian Iron Works.
	2	3	9 6	8 0	22	...	1,200	Not yet completed. Elements given are as designed.	Harlan & Hollingsworth.
[i]	2	3	10 6	7 6	27.6[e]	...	1,080	do.	Wolff & Zwicker.
	...	...	...	...	.....	...	1,200	do.	Gas Engine and Power Co.
5	2	...	...	...	.....	...	1,050	do.	Contract not let.
5	2	...	...	...	.....	...	1,200	do.	Contract not let.

each engine.

May 4, 1898, "making appropriations for the naval service for the fiscal year ending June 30, 1899, and for other purposes," the Department, in advertising for torpedo-destroyers, will invite proposals for vessels of about 400 tons trial displacement, and for torpedo boats of about 150 tons trial displacement, under two classes, viz:

"CLASS 1.—For the construction of the hull and machinery, including engines, boilers, and their appurtenances, and for equipment, complete in all respects, in accordance with the plans and specifications provided by the Secretary of the Navy, and for the installation of ordnance and ordnance outfit.

"CLASS 2.—For the construction of the hull and machinery, including engines, boilers, and their appurtenances, and for equipment, complete in all respects, in accordance with plans and specifications submitted by the bidder, and for the installation of ordnance and ordnance outfit in accordance with the requirements of the Department."

In order that ample time may be given all ship and marine-engine builders who may desire to submit their own plans of the hull and machinery, or of either, this circular defining the general requirements of the vessels is issued.

Bidders may, if they so desire, adopt the plans and specifications of the Department for the hull and machinery, or any part of either, and embody them in their plans and specifications to be submitted with their proposals.

The specifications submitted by the bidders under Class 2 must cover fully the ground covered by the Department's specifications. Copies of the Department's specifications will be furnished, in which bidders must show by erasures and additions the exact nature of the hull and machinery, including engines, boilers, and equipment, complete in all respects, that they propose to build.

Any specifications submitted must contain certain customary general requirements usually embodied in specifications prepared by the Department, and must be so drawn as to cover the detailed requirements of the Bureaus of Construction and Repair, Steam Engineering, Ordnance, and Equipment, of the Navy Department. For further information concerning such detailed requirements, application should be made to the respective bureaus concerned.

Any and all designs submitted must be accompanied by complete plans and specifications for building, and such calculations of weights, displacement and stability as will demonstrate the

satisfactory strength and stability of the whole structure, and no bids will be considered unless accompanied by such data.

In considering bids submitted, the Department will give due preference, other things being equal, to such designs as are considered best suited for the U. S. naval service, and among the matters of importance to be considered in this connection are—

The highest practicable speed guaranteed;

Designs showing the best seagoing qualities and giving the best protection to engines and boilers;

Shortest time within which bidders will guarantee completion of vessels.

The Department will reserve the right to reject any and all bids not considered advantageous to the Government, and no bids will be considered which propose to guarantee a speed of less than 28 knots for destroyers or less than 26 knots for boats.

The cost of the destroyers must not average more than $295,000 each in any bid, and the cost of boats not more than $170,000 each.

The destroyers and boats are to be built and fitted complete for sea by the contractors, with the exception of sea stores, ordnance, and outfit, and such other articles as are enumerated to be supplied by the Government. The contractors will fit and secure in place all ordnance and ordnance outfit.

While the words "about 400 tons displacement" and "about 150 tons displacement" are intended to allow some latitude to bidders, bids upon vessels of less displacement than the figures indicated will not be considered; nor will bids be considered for torpedo-boat destroyers of more than 435 tons at trial displacement, nor for torpedo boats of more than 170 tons at trial displacement, it being desired by the Department to obtain vessels having similar characteristics as near the displacement specified by the Act authorizing the same as is practicable.

Bidders under either Class 1 or Class 2 must state specifically the time of completion for the destroyers and boats included in their bids. Bids naming more than eighteen months for the completion of the torpedo-boat destroyers and twelve months for the torpedo boats will not be considered. The maximum time of completion will be limited by the Department to eighteen months for the destroyers and twelve months for the boats; and failure to complete the vessels within the times specified in the contracts will involve penalties as follows: In the case of the destroyers $50 a day for the first month next succeeding the expiration of the period fixed above, $100 a day for the second month, and $150 a day thereafter until delivery as required; and in the case

of the boats, $30 a day for the first month next succeeding the expiration of the period fixed above, $60 a day for the second month, and $100 a day thereafter until delivery as required, Sundays always excepted.

ELEMENTS OF DESIGN.

Destroyers.

The torpedo-boat destroyers will be about 400 tons trial displacement.

They are to have twin screws; vertical engines, to be placed in separate water-tight compartments, each with a condenser; water tubular boilers, and a bunker capacity for carrying at least 100 tons of coal, affording some protection to engines and boilers.

The vessels will be lighted throughout by electricity and furnished with one search light of an approved pattern.

They are to be built staunch and strong, with good free board, good seagoing qualities, and designed to operate at high speed in a sea way. They are to have two conning towers, the forward one of which will be made of $\frac{1}{2}$-inch nickel-steel plates.

The battery will be composed of seven rapid-firing guns in approved positions on deck or conning towers, which, with their mounts and fittings will weigh about 8 tons. The ammunition required will weigh about 7 tons. There will be mounted on the midship line two 20-foot torpedo tubes to carry 17-foot torpedoes, weighing in all 4 tons, and a space below will be required for stowing the two spare torpedoes and four war heads. Total ordnance weights will amount to about 24 tons.

Berthing space will be required to accommodate a crew of sixty men and four officers, and provision space for twenty days.

The following weights, in tons of 2,240 pounds each, are to be carried on trial in addition to completed hull and machinery, and spare parts, with fresh water necessary for trial:

Ordnance, tons,	15
Coal, tons,	25
Crew, stores, equipments, etc., tons,	12
In all, tons,	52

and with this weight on board they are to have a trial displacement at the commencement of the trial within the limits heretofore specified (400 tons to 435 tons). If, on trial, the average speed of the torpedo-boat destroyers for the two hours' trial falls below the speed guaranteed by the bidder, it may be accepted by the Department at a reduction at the rate of $8,000 for each quar-

ter of a knot. If the speed falls below 28 knots, the vessel will be rejected.

Torpedo Boats.

The torpedo boats will be of about 150 tons trial displacement. They are to have twin screws; vertical engines, placed in separate water-tight compartments, each with a condenser; water tubular boilers, and a bunker capacity for at least 40 tons of coal.

The vessels will be lighted throughout by electricity and furnished with one search light of an approved pattern.

They are to be built staunch and strong for the service intended, of good free board and seagoing qualities, and capable of operating at high speed in a moderate sea way. They are to have two conning towers, the forward one of which will be of ½-inch nickel-steel plates.

The battery will be composed of three rapid-firing guns and mounts, weighing about 2 tons, with 3½ tons of ammunition.

There will be mounted on deck, in approved positions, three 15-foot torpedo tubes, with torpedoes, and stowage space below for two additional torpedoes and five war heads. Total of all ordnance weights will amount to about 13 tons.

Berthing space will be provided for a crew of 26 men and 3 officers, and provision space for twenty days.

The following weights, in tons of 2,240 pounds each, are to be carried on trial in addition to completed hull and machinery, and spare parts, with fresh water necessary for trial:

Ordnance, tons, ...	9
Coal, tons, ...	10
Crew, stores, equipments, etc., tons, . .	8
In all, tons, ...	27

and with this weight on board they are to have a trial displacement at the commencement of the trial within the limits heretofore specified (150 tons to 170 tons). If, on trial, the average speed of the torpedo boats for the two hours' run falls below the speed guaranteed by the bidder, they may be accepted by the Department at a reduction at the rate of $3,000 for each quarter of a knot. If the speed falls below 25 knots the boat will be rejected.

The machinery for the destroyers, designed by the Bureau of Steam Engineering, consists of twin-screw, vertical, triple-expansion engines, each with a H.P. cylinder 20½ inches, an I.P. 32

inches and two L.P.'s, each 38 inches in diameter; the stroke is 22 inches. The I.H.P. of main engines, will be about 8,000 at about 327 revolutions per minute, the steam pressure at engines being 250 pounds. The engines will be in separate water-tight compartments.

The cranks are arranged in the following order from forward: Starboard engine, second L.P., I.P., H.P., first L.P.; port engine, first L.P., H.P., I.P., second L.P. The cranks are at angles of 90 degrees, the H.P. and first L.P. being opposite, as are the I.P. and second L.P. The weights of the pistons are to be such as to make the weights of reciprocating parts the same for all cylinders, the weights of air-pump pistons and moving parts actuating them being taken into account. If contractors prefer any other system of balancing, it will be given consideration. The balancing of rotating weights by counterweights on crank webs is left optional with the contractors.

The valve gear is of the Stephenson type with double-bar links, driving the valves direct.

The shafts, piston rods, connecting rods and working parts generally will be of forged high-grade steel, oil-tempered and annealed.

There will be a condenser for each engine with about 3,470 square feet of cooling surface. There will be two double-acting vertical air-pumps for each condenser, worked from the H.P. and I.P. crossheads. There is one centrifugal circulating pump to each condenser.

The boilers will be four in number, of the water-tube type, designed for 300 pounds working pressure. Two will be forward and two aft of the engines. Three of the boilers will have about 80.5 square feet of grate surface each, and the forward boiler about 73.5 square feet, the length of grates not exceeding 7 feet. The total grate surface will be at least 315 square feet, and the total heating surface at least 17,768 square feet. There will be four smoke pipes, one to each boiler. There will be two blowers in each fire room for forced draft.

The total weight of machinery, including auxiliaries, heaters, water in boilers, pipes, condensers and feed tanks, and the stores

and spare parts carried when fully equipped, is not to exceed 190 tons.

The main valves for cylinders are to be of the piston type, double ported for steam; they will not have packing rings, but will be turned and polished with emery to fit the liners accurately.

The piston rods will be of forged steel and hollow, 4¼ inches outside diameter and 2¾ inches inside diameter. The connecting rods also will be hollow, with a hole 2¼ inches diameter throughout the entire length. The engine framing will be of forged-steel columns, stiffened by forged-steel braces. The shafting will also be hollow and of forged steel.

The stern-tube bearings will be of white metal, in which the brass casing of the shaft will run; the bracket bearings will also be lined with white metal.

The air-pumps will be of the Bailey type, that is, there are no suction valves, and the whole cylinder cover is the delivery valve, the suction port being at the center.

The boiler-gauge glasses are to be of the automatic self-closing pattern, the glass being protected by a woven wire screen. There will be a hydraulic ash ejector in each fire room.

All steam piping above 2 inches diameter is to be of steel, seamless-drawn or lap-welded. The flanges will be of stamped or forged steel and must not be secured by a screwed connection. The flanges for pipes subjected to more than 200 pounds pressure will be male and female. The jointing material will be corrugated copper, asbesto-metallic or other approved material. Copper piping exposed to salt water will have inside surface treated with asphaltum varnish or other approved varnish applied hot.

The boilers and parts subjected to boiler pressure will be tested to 410 pounds; steam cylinders of auxiliary engines to 360 pounds; H.P. cylinders and valve chests to 360 pounds; I.P. cylinders and connections to 175 pounds; L.P. cylinders to 90 pounds; condensers to 30 pounds; feed pumps and connections to 450 pounds.

The machinery of the torpedo boats, as designed by the Bureau of Steam Engineering, consists of twin-screw, vertical,

WARSHIPS AND AUXILIARY VESSELS RECENTLY ACQUIRED BY THE UNITED

[Reprinted from "Marine Engineering

Old name and date.	Old class.	Length.	Breadth.	Depth.	Draught.	Displacement.	Horse power.	Speed.	Where
		ft. ins.	*ft. ins.*	*ft. ins.*	*ft. ins.*	*tons.*		*knots.*	
Abarenda, '92	Steel freighter.	314	42	26	...	2,123 gross.	250 N.	8	Newcastle on-T
Active, '88	Tug.	100	22 6	12 6	...	174 "	500	...	San Fra
Aileen, '96	Yacht.	140	20	15	8 9	151 net.	...	16	John R
Albatross, '82	U. S. Fish steamer.	200	27 6	16 9	12	639 gross.	289	9	Wilmin
Algonquin, '98	U. S. Revenue Cutter.	205	32	17	11 6	906	2,500	18	Globe Iron
Celtic King, '91	Steel, meat and cargo steamship.	371 8	42 2	27 2	...	3,738 gross.	360 N.	12	Workman, Clark
C. G. Coyle	Iron tug.	91 4	21	10 3	...	152 "	...	...	.....
Chatham, '84	Coast liner.	270	42	34	...	2,729 "	1,800	...	Philadelp
Corsair, '91	Steam yacht.	204	27	16 5	13	560 "	1,900	18	Neafie &
C P. Patterson, '83	U. S. Survey steamer.	175	27 3	...	14 2	718	350	9	Brooklyn,
Enterprise. '90	Tug.	91 6	21	10	...	124 gross.	...	...	Camden,
Fearless, '92	Steel tug.	145	26	16	...	400 "	1,200	...	San Fra
Felicia, '98	Steam yacht.	142	20	11	6	...	1,200	17	J. M. Rob
Fish Hawk. '79	U. S. Fish steamer.	146 6	27	10 9	8 6	442 "	...	9	Wilmingto
Free Lance, '79	Yacht.	109	20	10	7	90 net.	600	16	Lewis N
Gedney, '75	U. S. Survey steamer.	140	23 8	10 4	6 9	174 gross.	250	8	New Y
Gresham, '97	U. S. Revenue cutter.	205	32	17	11 6	906	2,500	18	Globe Iron
Harlech. '97	Freighter.	235 2	34 3	14 3	...	1,282 gross.	160 N.	...	Sunderland,
Hercules, '88	Tug.	101 5	20 6	10 8	...	142 "	...	14	J. H. Dialog
Hortense, '93	Steel tug.	102	21	9 6	...	130 "	...	...	" "
Illowawa, '96	Steam yacht.	106 3	18 6	10 6	8 2	119 "	...	13	Bath Iron
Illinois, '73	Transatlantic liner.	343	43	32 1	25	3,126 "	1,200	10.5	Cram
John Dwight, '96	Steam lighter.	120	27 3	7 9	7	151 "	...	...	Roderwal
Justin, '91	Steel freighter.	277	39	18 2	...	2,206 "	200 N.	10	Middles
Kingtor, '96	Steel freighter.	310	44	20 5	...	2,738 "	250 N.	9	Ropner & So
Louis McLane, '65	Side-wheel revenue cutter.	163	28	11 2	6	315 "	410	10.5	Transferred fro
McArthur, '76	U. S. Survey steamer.	115	20	...	12	130 "	...	...	Mare Isla
**Menemsha*, '85	Freighter.	304 3	38 8	26 5	...	2,716 "	220 N.	...	Newcastle-on-Ty
New York, '89	Transatlantic liner.	560	63 2	39 2	26 6	13,300	20,000	21.8	Clydebank,
Paris, '88	Transatlantic liner.	560	63 2	39 2	26 6	13,300	20,000	21	"
Penelope, '93	Steel yacht.	218	27	16	...	541 gross.	750	14	Leith, Sc
Pennwood, '92	Iron tug.	101 8	21 8	11 3	...	156 "	...	...	Sparrows Po
Philadelphia, '96.	Pilot boat.	140 8	25	14 6	12	300 "	700	15	Neafie &
Restless, '87	Yacht.	104	16	8 8	...	104	550	12	Houston & W
Right Arm, '91	Tug.	124 4	27	10 5	...	238 gross.	...	...	Athens,
Southery, '89	Freighter.	288	38 8	18 3	...	2,068 "	1,000	9	Sunderland,
Thespia, '95	Steam yacht.	169	23 3	13	9 10	312 "	600	12	Cram
T P. Fowler, '93	Tug.	97 6	24	11	...	161 "	...	...	Newburg,
Venezuela, '89	W. I. liner.	303 6	40 2	27 9	19 6	2,843 "	2,500	15	Cram
Vigilant, '83	Tug.	107	21	12 8	...	177 "	280	...	Philadelph
Viking, '83	Yacht.	125 6	20 6.	10 4	9	141 "	...	13	John Ro
W. H. Brown, '97	Tug.	156 8	28	17	13	833 "	2,000	17	F. W. Wheeler & W
Yorktown, '94	Coast liner.	300	40	34	20	2,898 "	3,500	16	John Ro
Yumuri, '89	W. I. liner.	336 2	43 2	22 3	18	3,497 "	2,600	14	"
Confidence, '80	Iron tug.	85	17 6	9 5	...	85 "	...	...	Philadelph
Elfrida, '89	Steel yacht.	102	18	12 6	7 11½	123	215	10.6	Harlan & Hol
Elizabeth Holland, '98	Steel freighter.	254	39 3	17 2	17 7¾	1,801	1,100	13	Sunderland,
Hercules, '88	Iron tug.	110	21	11	...	141 gross.	550	14	Camden,
Ice Boat, No. 3, '73	Ice boat.	195 9	33 3	...	12	...	...	...	.....
Joseph Holland, '98	Steel freighter.	254	39 3	17 2	17 7¾	1,801	1,100	13	Sunderland,
Kanawha. '96	Wood yacht.	146	17	10 6	7	127 gross.	600	14	Seabury,
Lighter, No. 18	Wood tow barge.	94 6	23 8	6 3	2 3	...	...	...	.....
No. 295, '98	Steel yacht.	153	20	10 6	8 6	159 "	550	16	Roach's Yard
Norse King, '90	Freight steamer.	340	41 1	26 3	23	2,985 "	440 N.	...	Sunderland,
Oil Barge, No. 55	Tow barge.	120	30	10	7	...	...	...	.....
† *Pedro*, '83	Iron freighter.	330 2	38 3	27 8	...	2,872 "	400 N.	10	Newcastle-on-Ty
Port Chalmers, '91	Steel meat steamer.	371	46 1	27 7	...	4,154 "	459 N.	8	Sunderland,
Ravenna, '82	Freight, passenger steamer.	393	40	28	17 8	3,256	3,000	14.5	Denny, Dunbart
Sylvia, '82	Iron yacht.	130	18 6	9 4	8 6	136 gross.	...	13	Stephens, G
‡ *Titania*, '79	Iron freighter.	282 6	35	24 2	...	1,966	250 N.	...	Sunderland,
Atala, '94	Steel freighter.	330	43	26 3	...	3,250 reg.	267 N.	9	Stockton, E
A. W. Booth, '98	Steel tug.	92 10	19	10	8	208 disp.	300	10.5	Neafie &
§ *City of Peking*, '74	Transpacific liner.	423	48	27 8	...	5,080 gross.	...	14	John Ro
Comanche, '92	Auxiliary yacht.	184 6	25	14 3	11	357	550	11	Globe Iron
Dorothea, '98	Yacht.	215	23 3	15	10	...	...	16.5	Cram
East Boston, '92	Twin screw ferry.	163	57	14	8 10	732 gross.	700	12	East Bos
Enquirer, '96	Yacht.	143 7	57 6	10	6	140.36	...	18	Union Dry Dock C

UNITED STATES NAVY BY PURCHASE, CHARTER OR TRANSFER.

Engineering."]

Where built.	Hailing port.	Former owners.	New class.	New name.
wcastle on-Tyne, England.	Newcastle.	Graham S. S. Co.	Collier.	*Abarenda.*
San Francisco.	San Francisco.	J. D. Spreckels & Bros. Co.	Tug.	*Active.*
John Roach.	New York.	Richard Stevens.	Auxiliary gunboat.	*Aileen.*
Wilmington.	...	U. S. Fish Commission.	Gunboat.	*Albatross.*
Globe Iron Works.	Great Lakes.	U. S. R. C. S.	Auxiliary gunboat.	*Accomac.*
kman, Clark & Co., Belfast.	London.	Federal S. N. Co.	Supply ship.	*Celtic.*
.....	...	.....	.....	*Choctaw.*
Philadelphia, Pa.	Baltimore.	Merchants' & Miners' T. Co.	Repair ship.	*Vulcan.*
Neafie & Levy.	New York.	J. P. Morgan.	Auxiliary gunboat.	*Gloucester*
Brooklyn, N. Y.	Pacific Coast.	U. S. Coast Survey.	.....	*Patterson.*
Camden, N. J.	...	Hy. Brown.	Tug.	*Modoc.*
San Francisco.	San Francisco.	J. D. Spreckels & Bros. Co.	"	*Iroquois.*
J. M. Robbins Co.	New York.	E. W. Bliss.	Auxiliary gunboat.	*Uncanoomuck.*
Wilmington, Del.	Wilmington, Del.	U. S. Fish Commission.	Gunboat.	*Fish Hawk.*
Lewis Nixon.	New York.	F. A. Schermerhorn.	Auxiliary gunboat.	*Free Lance.*
New York.	...	U. S. Coast Survey.	.....	*Gedney.*
Globe Iron Works.	U. S. R. C. S.	U. S. R. C. S.	Auxiliary gunboat.	*Gresham.*
Sunderland, England.	London.	J. & C. Harrison.	Collier.	*Pompey.*
J. H. Dialogue & Son.	New York.	Standard Oil Co.	Tug.	*Hercules.*
" " "	Galveston.	Galveston Cons. Co.	"	?
Bath Iron Works.	Boston.	Eugene Tompkins.	Auxiliary gunboat.	*Oneida.*
Cramp.	New York.	International Navigation Co.	Provision ship.	*Supply.*
Roderwald & Co.	...	.....	Lighter.	*Pawnee.*
Middlesboro.	London.	Eng. & Amer. Shipping Co.	Collier.	*Justin.*
Ropner & Son, St'kt'n.	"	J. Holman & Son.	"	*Cæsar*
ansferred from Navy, '65.	Key West.	U. S. R. C. S.	Pilot and scout.	*L. McLane.*
Mare Island, Cal.	Pacific Coast.	U. S. Coast Survey.	.....	*McArthur.*
wcastle-on-Tyne, England.	New York.	T. Hogan & Son.	Water ship.	*Iris.*
Clydebank, Scotland.	"	International Navigation Co.	Auxiliary cruiser.	*Harvard.*
" "	"	" "	" "	*Yale.*
Leith, Scotland.	Boston.	H. E. Converse.	Auxiliary gunboat.	*Yankton.*
Sparrows Point, Md.	...	J. R. Ford Trans. Co.	Tug.	*Powhattan.*
Neafie & Levy.	Philadelphia.	Philadelphia Pilots.	Miscellaneous.	*Peoria.*
Houston & Woodbridge.	"	H. W. Sibley.	Auxiliary gunboat.	*Restless.*
Athens, N. Y.	New York.	.....	Tug.	*Pontiac*
Sunderland, England.	St. John.	T. E. Morrison.	Collier.	*Southery.*
Cramp.	New York.	David Dows, Jr.	Auxiliary gunboat.	*Hist.*
Newburg, N. Y.	Albany, N. Y.	.....	Water boat.	*Mohawk.*
Cramp.	Wilmington, Del.	Red D Line.	Auxiliary cruiser.	*Panther.*
Philadelphia, Pa.	San Francisco.	J. D. Spreckels & Bros. Co.	Tug.	*Vigilant.*
John Roach.	New York.	Horace C. Hutchins.	Auxiliary gunboat.	*Viking.*
V. Wheeler & Co., West Bay City.	Pittsburgh.	W. H. Brown.	Water boat.	*Piscataqua.*
John Roach.	New York.	Old Dominion S. S. Co.	Auxiliary cruiser.	*Resolute.*
" "	"	J. E. Ward & Co.	Armed transport.	*Badger.*
Philadelphia, Pa.	Boston.	.....	Tug.	*Waban.*
Harlan & Hollingsworth.	Shelbourne, Vt.	Dr. W. Seward Webb.	Auxiliary gunboat.	*Elfrida.*
Sunderland, England.	British.	F. S. Holland.	Collier.	*Leonidas.*
Camden, N. J.	New York.	Standard Oil Co.	Tug.	*Chickasaw.*
.....	Philadelphia.	City of Philadelphia.	Coast patrol.	*Arctic.*
Sunderland, England.	British.	.....	Collier.	*Hannibal.*
Seabury, Nyack.	New York.	John P. Duncan.	Auxiliary gunboat.	*Kanawha.*
.....	Philadelphia.	Phil. Trans. & L't'ge Co.	.....	*Trans. Lighter.*
Roach's Yard, Chester.	...	Del. River Iron Ship. Bldg. & Engine Works.	Auxiliary gunboat.	*Sylph.*
Sunderland, England.	London.	W. Ross & Co.	Distilling ship.	*Rainbow*
.....	New York.	Standard Oil Co.	Water barge.	*Water Barge, No. 1*
wcastle-on-Tyne, England.	Bilbao.	Cia de Nav., La Flecha.	Collier.	*Hector.*
Sunderland, England.	London.	Federal S. N. Co.	Supply ship.	*°Glacier.*
ny, Dunbarton, Scotland.	...	.....	Collier.	*Scipio.*
Stephens, Glasgow.	New York.	Ed. M. Brown.	Auxiliary gunboat.	*Sylvia.*
Sunderland, England.	Hamburg.	A. Kirsten.	Collier.	*Marcellus.*
Stockton, England.	London.	New Blue Star Line, Ltd.	"	*Alexander.*
Neafie & Levy.	New York.	Michael Moran.	Tug.	*Massassoit.*
John Roach.	San Francisco.	Pacific Mail S. S. Co.	Miscellaneous.	*City of Peking.*
Globe Iron Works.	Cleveland.	H. M. Hanna.	Auxiliary gunboat.	*Frolic.*
Cramp.	Philadelphia.	Estate of Thos. McKean.	" "	*Dorothea.*
East Boston.	Boston.	Street Dept., Boston.	" "	*East Boston.*
Dry Dock Co., Buff., N. Y.	Buffalo.	J. W. Connors.	Auxiliary gunboat.	*Enquirer.*
Leith, Scotland.	Philadelphia.	J. G. Cassatt.	" "	*Huntress.*

Albatross, '82	U. S. Fish steamer.	200		27	6	16	9	12		639 gross.	289	9	Wilmi
Algonquin, '98	U. S. Revenue Cutter.	205		32		17		11	6	906	2,500	18	Globe Iro
Celtic King, '91	Steel, meat and cargo steamship.	371	8	42	2	27	2	...		3,738 gross.	360 N.	12	Workman, Clar
C. G. Coyle	Iron tug.	91	4	21		10	3	...		152 "	...	...	....
Chatham, '84	Coast liner.	270		42		34		...		2,729 "	1,800	...	Philadel
Corsair, '91	Steam yacht.	204		27		16	5	13		560 "	1,900	18	Neafie
C. P. Patterson, '83	U. S. Survey steamer.	175		27	3	...		14	2	718	350	9	Brookly
Enterprise, '90	Tug.	91	6	21		10		...		124 gross.	...	...	Camde
Fearless, '92	Steel tug.	145		26		16		...		400 "	1,200	...	San Fr
Felicia, '98	Steam yacht.	142		20		11		6		...	1,200	17	J. M. Ro
Fish Hawk, '79	U. S. Fish steamer.	146	6	27		10	9	8	6	442 "	...	9	Wilming
Free Lance, '79	Yacht.	109		20		10		7		90 net.	600	16	Lewis
Gedney, '75	U. S. Survey steamer.	140		23	8	10	4	6	9	174 gross.	250	8	New
Gresham, '97	U. S. Revenue cutter.	205		32		17		11	6	906	2,500	18	Globe Iro
Harlech, '97	Freighter.	235	2	34	3	14	3	...		1,282 gross.	160 N.	...	Sunderland
Hercules, '88	Tug.	101	5	20	6	10	8	...		142 "	...	14	J. H. Dialo
Hortense, '93	Steel tug.	102		21		9	6	...		130 "	...	...	" "
Illawarra, '96	Steam yacht.	106	3	18	6	10	6	8	2	119 "	...	13	Bath Iron
Illinois, '73	Transatlantic liner.	343		43		32	1	25		3,126 "	1,200	10.5	Cra
John Dwight, '96	Steam lighter.	120		27	3	7	9	7		151 "	...	...	Roderwa
Justin, '91	Steel freighter.	277		39		18	2	...		2,206 "	200 N.	10	Middle
Kingtor, '96	Steel freighter.	310		44		20	5	...		2,738 "	250 N.	9	Ropner & S
Louis McLane, '65	Side-wheel revenue cutter.	163		28		11	2	6		315 "	410	10.5	Transferred fr
McArthur, '76	U. S. Survey steamer.	115		20		...		12		130 "	...	...	Mare Isl
**Menemsha*, '85	Freighter.	304	3	38	8	26	5	...		2,716 "	220 N.	...	Newcastle-on-T
New York, '89	Transatlantic liner.	560		63	2	39	2	26	6	13,300	20,000	21.8	Clydebank,
Paris, '88	Transatlantic liner.	560		63	2	39	2	26	6	13,300	20,000	21	"
Penelope, '93	Steel yacht.	218		27		16		...		541 gross.	750	14	Leith, S
Pennwood, '92	Iron tug.	101	8	21	8	11	3	...		156 "	...	...	Sparrows
Philadelphia, '96	Pilot boat.	140	8	25		14	6	12		300 "	700	15	Neafie &
Restless, '87	Yacht.	104		16		8	8	...		104	550	12	Houston & W
Right Arm, '91	Tug.	124	4	27		10	5	...		238 gross.	...	...	Athens,
Southery, '89	Freighter.	288		38	8	18	3	...		2,068 "	1,000	9	Sunderland,
Thespia, '95	Steam yacht.	169		23	3	13		9	10	312 "	600	12	Cra
T. P. Fowler, '93	Tug.	97	6	24		11		...		161 "	...	...	Newburg
Venezuela, '89	W. I. liner.	303	6	40	2	27	9	19	6	2,843 "	2,500	15	Cra
Vigilant, '83	Tug.	107		21		12	8	...		177 "	280	...	Philadelp
Viking, '83	Yacht.	125	6	20	6	10	4	9		141 "	...	13	John R
W. H. Brown, '97	Tug.	156	8	28		17		13		833 "	2,000	17	F. W. Wheeler
Yorktown, '94	Coast liner.	300		40		34		20		2,898 "	3,500	16	John R
Yumuri, '89	W. I. liner.	336	2	43	2	22	3	18		3,497 "	2,600	14	"
Confidence, '80	Iron tug.	85		17	6	9	5	...		85 "	...	...	Philadelp
Elfrida, '89	Steel yacht.	102		18		12	6	7	11½	123	215	10.6	Harlan & Ho
Elizabeth Holland, '98	Steel freighter.	254		39	3	‖17	2	17	7¾	1,801	1,100	13	Sunderland,
Hercules, '88	Iron tug.	110		21		11		...		141 gross.	550	14	Camden
Ice Boat, No. 3, '73	Ice boat.	195	9	33	3	...		12		...	...	...	.....
Joseph Holland, '98	Steel freighter.	254		39	3	‖17	2	17	7¾	1,801	1,100	13	Sunderland,
Kanawha, '96	Wood yacht.	146		17		10	6	7		127 gross.	600	14	Seabury,
Lighter, No. 18	Wood tow barge.	94	6	23	8	6	3	2	3	...	...	...	.....
No. 295, '98	Steel yacht.	153		20		10	6	8	6	159 "	550	16	Roach's Yar
Norse King, '90	Freight steamer.	340		41	1	26	3	23		2,985 "	440 N.	...	Sunderland,
Oil Barge, No. 55	Tow barge.	120		30		10		7		...	...	...	.....
†*Pedro*, '83	Iron freighter.	330	2	38	3	27	8	...		2,872 "	400 N.	10	Newcastle-on-T
Port Chalmers, '91	Steel meat steamer.	371		46	1	27	7	...		4,154 "	459 N.	8	Sunderland,
Ruvenna, '82	Freight, passenger steamer.	393		40		28		17	8	3,256	3,000	14.5	Denny, Dunbar
Sylvia, '82	Iron yacht.	130		18	6	9	4	8	6	136 gross.	...	13	Stephens,
‡*Titania*, '79	Iron freighter.	282	6	35		24	2	...		1,966	250 N.	...	Sunderland,
Atala, '94	Steel freighter.	330		43		26	3	...		3,250 reg.	267 N.	9	Stockton,
A. W. Booth, '98	Steel tug.	92	10	19		10		8		208 disp.	300	10.5	Neafie &
§*City of Peking*, '74	Transpacific liner.	423		48		27	8	...		5,080 gross.	...	14	John R
Comanche, '92	Auxiliary yacht.	184	6	25		14	3	11		357	550	11	Globe Iro
Dorothea, '98	Yacht.	215		23	3	15		10		...	...	16.5	Cran
East Boston, '92	Twin screw ferry.	163		57		14		8	10	732 gross.	700	12	East B
Enquirer, '96	Yacht.	143	7	57	6	10		6		140.36	...	18	Union Dry Dock
Eugenia	Yacht.	149	6	19		11	6	10		165 gross.	360	11.75	Leith, Sc
Governor Russell, '98	Twin screw ferry.	164	3	57		14	1	9		713	700	12	East B
Huntress, '95	Yacht.	120		16		9		6	6	81.76	650	16	C. L. Se
Inca, '79	Yacht.	92	6	20		9	5	7		103 gross.	200	12	Philadelp
J. D. Jones, '89	Wood tug.	140	9	29		12	4	11	6	298 "	525	10	Tottenvill
Kate Jones, '79	Iron tug.	102	5	20		10	6	...		122 "	125 N.	...	Camden
Peter Jebsen, '94	Freighter.	321	5	41	5	21	9	...		3,070 "	283 N.	8	South Shields
¶*Rhaetia*, '83	Steel freight and passenger steamer.	351	6	43		29		...		3,458 "	440 N.	10	Hamburg,
Scindia, '90	Do.	375		46		27		...		4,358 "	440 N.	12.5	D. & W. Hende
Shearwater, '87	Yacht.	120		18		10		8		109 "	220	11	Boston,
Stranger, '80	Yacht.	190	5	23	8	11	6	10	6	247 "	...	...	Cran
Whitgift, '95	Steel freight and passenger steamer.	312		41		20	6	...		2,925 "	246 N.	9	Sunderland,

* Formerly British S. S. *Dryden*.

† Captured by Blockading Fleet in Cuban waters. The *Pedro* was formerly the S. S. *Lilburn Tower*.

¶ Formerly in Hamburg-American Fleet.

‡ For

‖ Hold.

° Tem

Wilmington.	...	U. S. Fish Commission.	Gunboat.	*Albatross.*
Globe Iron Works.	Great Lakes.	U. S. R. C. S.	Auxiliary gunboat.	*Accomac.*
orkman, Clark & Co., Belfast.	London.	Federal S. N. Co.	Supply ship.	*Celtic.*
.....	...	.....	.....	*Choctaw.*
Philadelphia, Pa.	Baltimore.	Merchants' & Miners' T. Co.	Repair ship.	*Vulcan.*
Neafie & Levy.	New York.	J. P. Morgan.	Auxiliary gunboat.	*Gloucester*
Brooklyn, N. Y.	Pacific Coast.	U. S. Coast Survey.	.....	*Patterson.*
Camden, N. J.	...	Hy. Brown.	Tug.	*Modoc.*
San Francisco.	San Francisco.	J. D. Spreckels & Bros. Co.	"	*Iroquois.*
J. M. Robbins Co.	New York.	E. W. Bliss.	Auxiliary gunboat.	*Uncanoonuck.*
Wilmington, Del.	Wilmington, Del.	U. S. Fish Commission.	Gunboat.	*Fish Hawk.*
Lewis Nixon.	New York.	F. A. Schermerhorn.	Auxiliary gunboat.	*Free Lance.*
New York.	...	U. S. Coast Survey.	.....	*Gedney.*
Globe Iron Works.	U. S. R. C. S.	U. S. R. C. S.	Auxiliary gunboat.	*Gresham.*
Sunderland, England.	London.	J. & C. Harrison.	Collier.	*Pompey.*
J. H. Dialogue & Son.	New York.	Standard Oil Co.	Tug.	*Hercules.*
" " "	Galveston.	Galveston Cons. Co.	"	?
Bath Iron Works.	Boston.	Eugene Tompkins.	Auxiliary gunboat.	*Oneida.*
Cramp.	New York.	International Navigation Co.	Provision ship.	*Supply.*
Roderwald & Co.	...	.....	Lighter.	*Pawnee.*
Middlesboro.	London.	Eng. & Amer. Shipping Co.	Collier.	*Justin.*
Ropner & Son, St'kt'n.	"	J. Holman & Son.	"	*Cæsar*
Transferred from Navy, '65.	Key West.	U. S. R. C. S.	Pilot and scout.	*L. McLane.*
Mare Island, Cal.	Pacific Coast.	U. S. Coast Survey.	.....	*McArthur.*
ewcastle-on-Tyne, England.	New York.	T. Hogan & Son.	Water ship.	*Iris.*
Clydebank, Scotland.	"	International Navigation Co.	Auxiliary cruiser.	*Harvard.*
" "	"	" "	" "	*Yale.*
Leith, Scotland.	Boston.	H. E. Converse.	Auxiliary gunboat.	*Yankton.*
Sparrows Point, Md.	...	J. R. Ford Trans. Co.	Tug.	*Powhattan.*
Neafie & Levy.	Philadelphia.	Philadelphia Pilots.	Miscellaneous.	*Peoria.*
Houston & Woodbridge.	"	H. W. Sibley.	Auxiliary gunboat.	*Restless.*
Athens, N. Y.	New York.	.....	Tug.	*Pontiac*
Sunderland, England.	St. John.	T. E. Morrison.	Collier.	*Southery.*
Cramp.	New York.	David Dows, Jr.	Auxiliary gunboat.	*Hist.*
Newburg, N. Y.	Albany, N. Y.	.....	Water boat.	*Mohawk.*
Cramp.	Wilmington, Del.	Red D Line.	Auxiliary cruiser.	*Panther.*
Philadelphia, Pa.	San Francisco.	J. D. Spreckels & Bros. Co.	Tug.	*Vigilant.*
John Roach.	New York.	Horace C. Hutchins.	Auxiliary gunboat.	*Viking.*
W. Wheeler & Co., West Bay City.	Pittsburgh.	W. H. Brown.	Water boat.	*Piscataqua.*
John Roach.	New York.	Old Dominion S. S. Co.	Auxiliary cruiser.	*Resolute.*
" "	"	J. E. Ward & Co.	Armed transport.	*Badger.*
Philadelphia, Pa.	Boston.	.....	Tug.	*Waban.*
Harlan & Hollingsworth.	Shelbourne, Vt.	Dr. W. Seward Webb.	Auxiliary gunboat.	*Elfrida.*
Sunderland, England.	British.	F. S. Holland.	Collier.	*Leonidas.*
Camden, N. J.	New York.	Standard Oil Co.	Tug.	*Chickasaw.*
.....	Philadelphia.	City of Philadelphia.	Coast patrol.	*Arctic.*
Sunderland, England.	British.	.....	Collier.	*Hannibal.*
Seabury, Nyack.	New York.	John P. Duncan.	Auxiliary gunboat.	*Kanawha.*
.....	Philadelphia.	Phil. Trans. & L't'ge C'.	.....	*Trans. Lighter.*
Roach's Yard, Chester.	...	Del. River Iron Ship. Bldg. & Engine Works.	Auxiliary gunboat.	*Sylph.*
Sunderland, England.	London.	W. Ross & Co.	Distilling ship.	*Rainbow.*
.....	New York.	Standard Oil Co.	Water barge.	*Water Barge, No. 1*
ewcastle-on-Tyne, England.	Bilbao.	Cia de Nav., La Flecha.	Collier.	*Hector.*
Sunderland, England.	London.	Federal S. N. Co.	Supply ship.	°*Glacier.*
enny, Dunbarton, Scotland.	...	.....	Collier.	*Scipio.*
Stephens, Glasgow.	New York.	Ed. M. Brown.	Auxiliary gunboat.	*Sylvia.*
Sunderland, England.	Hamburg.	A. Kirsten.	Collier.	*Marcellus.*
Stockton, England.	London.	New Blue Star Line, Ltd.	"	*Alexander.*
Neafie & Levy.	New York.	Michael Moran.	Tug.	*Massasoit.*
John Roach.	San Francisco.	Pacific Mail S. S. Co.	Miscellaneous.	*City of Peking.*
Globe Iron Works.	Cleveland.	H. M. Hanna.	Auxiliary gunboat.	*Frolic.*
Cramp.	Philadelphia.	Estate of Thos. McKean.	" "	*Dorothea.*
East Boston.	Boston.	Street Dept., Boston.	" "	*East Boston.*
n Dry Dock Co., Buff., N. Y.	Buffalo.	J. W. Connors.	Auxiliary gunboat.	*Enquirer.*
Leith, Scotland.	Philadelphia.	J. G. Cassatt.	" "	*Huntress.*
East Boston.	Boston.	Street Dept., Boston.	Lighter.	*Governor Russell.*
C. L. Seabury.	Hartford, Conn.	F. C. Fowler.	Auxiliary gunboat.	*Huntress.*
Philadelphia, Pa.	Brunswick, Ga.	South Atlantic Tow Co.	" "	*Inca.*
Tottenville, N. Y.	New York.	Merritt Wrecking Co.	Tug.	*J. D. Jones.*
Camden, N. J.	Boston.	.....	"	*Seminole.*
South Shields, England.	Bergen.	Bergh & Helland.	Collier.	*Brutus*
Hamburg, Germany.	...	.....	"	*Cassius.*
& W. Henderson, Glasgow.	Glasgow.	Henderson Bros.	"	*Scindia.*
Boston, Mass.	New York.	H. R. Wolcott.	Auxiliary gunboat.	*Shearwater.*
Cramp.	"	Mrs. Mary Lewis.	" "	*Stranger.*
Sunderland, England.	London.	Houlder, Middleton & Co.	Collier.	*Nero.*

‡ Former names S. S. *C. Fellinger* and S. S. *Mercedes.*

° Temporarily named the *Delmonico.*

‡ Sailed with stores, etc., for Admiral Dewey's Squadron.

triple-expansion engines of 3,000 I.H.P. at 350 revolutions per minute and 250 pounds pressure. The cylinder diameters are H.P., 14 inches; I.P., 22 inches; and two L.P., 25½ inches; the stroke is 18 inches. The engines will be in separate water-tight compartments with the H.P. cylinders forward and L.P. cylinders aft. The framing consists of forged-steel columns, stayed by forged and cast-steel ties and braces.

The shafts, piston and connecting rods, valve rods and working parts generally will be of forged nickel steel.

There will be a condenser for each engine with 1,200 square feet of cooling surface. Each will have one double-acting Bailey air pump driven from main engine shaft, and one independent, centrifugal, circulating pump.

There will be three water-tube boilers with an aggregate grate surface of at least 137 square feet and heating surface of at least 7,544 square feet. Each boiler will have a separate smoke pipe. Two boilers will be forward and one abaft the engines.

The total weight of machinery, including same items as for destroyers, must not exceed 79.745 tons.

The connecting rods are to be flat, instead of round and hollow, as for the destroyers.

The valve gear will be the Stephenson double-bar link with crossed rods, the links being suspended in the middle.

The details generally follow the same specifications, except as to size, as the destroyers.

Vulcan.—We had hoped in this number to present a complete article on this interesting repair ship from the pen of one of her officers, but she has been employed so steadily that this has been impossible. The *Vulcan* arrived at Guantanamo, Cuba, July 1st, and has proved of the greatest service to the fleet. Her mechanics have been worked in three shifts so that the power tools have been running practically day and night. It would be almost easier to say what she has not done than what she has, for every ship and every department has received assistance. The torpedo boats, tugs and yachts, which have no power tools, have, of course, received most assistance, but work has been done for every ship. The brass furnaces have been run every day, and several heats

have been poured from the cupola for such work as grate bars, worm wheels, &c. This is very interesting as being the first instance on record where a cupola has been used on board ship. A great deal of work has been done on gun gear, made necessary by the great fight of July 3d, at Santiago. The ship has earned golden opinions from everybody, and has been pronounced an unqualified success. Her commanding officer reported, about the middle of July, that she had made repairs to twenty-six ships and had supplied stores to thirty-one.

Wheeling.—The following table contains some interesting data of four runs of the *Wheeling*, the weather conditions being generally favorable. The hull dimensions are 174.06 feet × 34 feet × 12.03 feet, and 1,000 tons displacement. There are two cylindrical boilers fitted with Howden draft, each having 30 square feet of grate and 1,254 square feet of heating surface.

Date of run.	November 7–15, 1897.*	January 2–3, 1898.†	Sept. 25–Oct. 2, 1897.††	June 17–20, 1898.‡
Number of hours	214	48	192.8	81.46
Speed per hour, knots	9.198	9.69	9.83	10.211
Knots per day	220.75	232.60	236.1	245.06
Coal per day, tons	13.26	12.29	13.16	15.40
Knots per ton	16.60	18.90	17.90	15.91
Fore-and-aft sail set, per cent. of time	34	26	26	26
Coal, kind	Nanaimo; poor.	Cardiff; good.	Westport; good.	Comox; fair.
Months out of dock	6	8	4	2

* Two boilers, $\frac{1}{8}$-inch to $\frac{3}{16}$-inch Howden draft.
† Two boilers, $\frac{1}{8}$-inch to $\frac{3}{16}$-inch Howden draft.
†† Two boilers, $\frac{1}{8}$-inch to $\frac{1}{4}$-inch Howden draft.
‡ Two boilers, $\frac{1}{4}$-inch Howden draft.

Marietta.—The accompanying table gives the steaming data of the *Marietta* during her voyage from San José de Guatamala to Key West, Florida. The runs were made under both boilers, which are of the Babcock and Wilcox type. The bottom was foul.

Date.	Hours.	Speed. Knots pr. hour.	Coal expenditure per day of 24 hours. Tons.	Knots.		Coal endurance.		Months out of dock.	Di ti
				Per day.	Per ton of coal.	In days.	In knots.		
March 16–21, 1898.....	120.35	8.36	15.90	200.64	12.61	15.4	3,202	7	
March 24–30, 1898.....	149.5	9.92	16.68	238.08	14.27	14.7	3,510	7	
March 31–April 7, 1898...	155.65	10.04	17.76	241.00	13.57	13.8	3,338	7	
April 10–15, 1898.....	137.3	10.078	18.31	241.87	13.20	13 4	3,247	8	
April 17, 1898.....	16.8	10.59	19.70	254.16	12.41	12.4	3,052	8	Vi
April 21–30, 1898.....	227.15	10.102	19.12	242.44	12.68	12.8	3,119	8	
May 5–11, 1898.....	137.15	7.808	13.69	187.39	13.69	17.9	3,367	9	
May 13–20, 1898.....	170.9	7.89	11.41	189.36	16.6	21.5	4,083	9	
May 22–June 4, 1898.....	307.41	9.005	13.31	216.12	16.23	18.48	3,992	10	

Total hours..... 1,422.21
Total coal, tons..... 928.28
Total knots..... 13,096.02

Months out of dock.	Wind.		Sea.	Kind and quality of coal.	Fore-and-aft sail carried. Per cent. of time.	Remarks.
	Direction.	Force.				
7	4	3	Smooth.	Australian; poor.	None.	San José de Guatamala to Panama.
7	3	2	S. to M.	Cumberland and mixed bituminous; fair.	4	Panama to Callao.
7	2	2	S. to M.	Cardiff and Comox; fair.	None.	Callao to Valparaiso.
8	6	3	M. to R.	Cardiff; good.	60	Valparaiso to Tuesday Bay, Magellan Strait.
8	Var.	3	Smooth.	Cardiff; good.	None.	Tuesday Bay to Sandy Point, Magellan Strait.
8	6	3	S. to M.	Welsh; good.	54	Sandy Point to Rio de Janeiro.
9	4	3	S. to M.	Cardiff and Newcastle; fair.	None.	Rio de Janeiro to Bahia, Brazil.
9	9	3	S. to M.	Cory's Merthyr; good.	48	Bahia to Para River, Brazil. Convoying *Nictheroy*.
10	8	2	S. to M.	Cardiff and Cumberland; fair.	60	Para River to Key West, Florida.

Knots per ton..... 14.10
Speed in knots for entire voyage..... 9.20
Radius of action at this rate..... 3,468

Upon arrival at Key West her machinery was reported in good condition, and the Engineer officer—Passed Assistant Engineer W. H. Chambers, U. S. N.—states that the slight repairs necessary to be made during stops for coal were always completed, and the machinery reported ready for sea, before the coaling was finished.

The bunker capacity of the *Marietta* is 246 tons of bituminous coal.

The hull dimensions are 174.06 feet × 34 feet × 12 feet; and displacement, 1,000 tons. There are two boilers, each having 47 square feet of grate and 1,832 square feet of heating surface.

Farragut.—The first torpedo-boat destroyer of our Navy, the *Farragut*, was successfully launched at the works of the Union Iron Works in San Francisco at 9·36 on the evening of Saturday, July 16th. The unusual hour was caused by the favorable condition of the tide at that time.

Mackenzie.—Another of the new United States torpedo boats, the *Mackenzie*, built by Charles Hillman & Co., of Philadelphia, had her builders' trial on the Delaware about the middle of June. The *Mackenzie* made her speed trial on a measured statute mile at Deep Water Point, on the Jersey side, almost opposite Wilmington, and she covered the distance in 2 minutes 55 seconds, almost equaling a speed of 21 knots per hour, 1 knot more than the contract calls for. This was accomplished, too, with her engine making only 294 revolutions to the minute. A test of her maneuvering qualities was made, and the vessel, while running at full speed, was turned six times in the space of double her length, which is 101½ feet. Both the naval officers and her builders are well satisfied. .

Resolute.—The *Resolute*, formerly the Old Dominion S. S. Co.'s steamer *Yorktown*, which was purchased by the Navy Department for use as an auxiliary cruiser, was one of the finest of our coastwise passenger boats. She was built at Roach's shipyard and plied between Norfolk, Va., and New York. For 200 consecutive voyages the average hour of arrival in New York of the *Yorktown*, *Jamestown* and *Princess Anne* has been 3·58 P. M., they being due between 3·30 and 4 P. M. Such uniformity of

speed in ocean vessels, covering a trip of over 300 miles in all kinds of wind and weather, is remarkable. The dimensions of the *Yorktown* are as follows: Length over all, 310 feet; breadth of beam, 40 feet, and depth of hold, 26 feet 9 inches. She is schooner rigged with steel masts. Her engines are of the triple-expansion condensing type, with cylinder diameters of 28, 44½ and 73 inches for the high, intermediate and low pressure, respectively, and a common stroke of 54 inches. The *Yorktown* was the second ship of that name running on this route. It is a curious coincidence that the first *Yorktown* was also used as a war vessel, having been seized by the Confederates. The first *Yorktown* was commanded by Capt. Jno. R. Tucker (now dead), and was eventually burnt on the evacuation of Richmond. She was a paddle-wheel ship, capable of making 12 knots an hour. She had accommodations for about 50 first-class passengers, and was considered a first-class coastwise vessel at that time.—"Seaboard."

Onondaga.—The United States revenue cutter *Onondaga*, built at the yard of the Globe Iron Works Co., Cleveland, was subjected in the latter part of July to two dock trials of two hours each and a builder's trial of eight hours' continuous steaming. On the latter trial a speed of 19 miles per hour was attained under natural draft. The engines worked perfectly and at no time did the journals become overheated. The screw attained 158 revolutions on a steam pressure of 155 pounds. The coal consumption is known to have been very economical, although no record of it was kept. It is probable that it will be fully ten days before the vessel is ready to leave on her official trip to Ogdensburg, where she will be cut in two for passage through the canals. The *Onondaga* is 205 feet over all, 32 feet beam and 17 feet deep and, except in minor details, is exactly similar to the *Algonquin*, which has already been cut in two and will start this week on her way through the canals.—"Marine Review."

Algonquin.—The builders' trial of the U. S. revenue cutter *Algonquin* in the lake opposite Cleveland, May 26, was eminently satisfactory to officials of the Globe Iron Works Co. and also to the representatives of the Government. Among the officials of

the revenue cutter service aboard during the trial were Capt. J. W. Collins, Assistant Engineer George Farkell, Capt. D. A. Hall, First Lieutenant J. H. Quinan, J. E. Jeffries and John R. Dally. Mr. Dally has been assigned to the position of chief engineer of the *Algonquin*.

The trip, being a builders' rather than a Governmental trial, was entirely under the direction of Supt. R. L. Newman of the Globe company. The *Algonquin* left her dock at 9 o'clock in the morning, and with the exception of a few minutes' delay at the commencement of the run for the adjustment of some loose bearings, steamed continuously for eight hours. The highest speed attained, 18.4 knots, equivalent to 20.8 statute miles, would seem to demonstrate the practical certainty of the vessel attaining a speed of 19 knots per hour when fully manned. One reason for the failure to attain a higher speed on the occasion of this test is found in the fact that the boilers were not clothed with non-conducting material, and there was in consequence considerable radiation. Moreover, an inferior kind of coal was used, and there were not on board a sufficient number of competent firemen.

The machinery worked smoothly and without a hitch, and at the maximum speed of 162 revolutions scarcely any vibration could be felt on the main deck. The regular final trial, which is required to be of twelve hours' duration, will take place between Cleveland and Ogdensburg. The builders have agreed to deliver the vessel at Ogdensburg, where she will be cut in two just forward of the forward boiler compartment and pontooned through the canals of the St. Lawrence to Montreal, where the Globe company will put her together again. The Navy Department has urged that both the *Algonquin* and *Onondaga*, also building at the Globe yards, reach the Atlantic coast as expeditiously as possible, as it is desired to utilize them as torpedo boats. The superiority of speed of the *Algonquin* to the *Gresham*, which on her official trial only developed 18.25 knots, is attributed to the fact that the former vessel has with the same horse power 70 tons less displacement.

In armament the *Algonquin* will be superior to the *Manning* and *McCulloch*, coast revenue cutters. The coast vessels are

fitted to carry three 4-inch rifles, a 6-pounder and six machine guns, while the *Algonquin* will carry an additional 4-inch rifle.—"Marine Review."

ARGENTINA.

Pueyrredon.—According to "Le Yacht," the Ansaldos have sold the armored cruiser *Garabaldi*, recently constructed by them, to the Argentines, who have named the vessel *Pueyrredon*.

The displacement is 6,840 tons, the I.H.P., 13,000, and the speed 20 knots. The vessel is of exactly the same type as the *Varese*, recently purchased. The preliminary trials have commenced at Genoa.

Varese.—A contract has been made with the Orlandos at Leghorn for the purchase of the armored cruiser *Varese*, originally built for the Italian Government. This vessel is of the same type as the *San Martin*, which recently attained without difficulty a speed of 19.7 knots.

General San Martin.—The cruiser *General San Martin* has lately been added to the Argentine Navy. This vessel was constructed and completely finished by Messrs. Orlando Brothers in their dockyard at Leghorn. Her principal dimensions are as follows: Length between perpendiculars, 100 meters (328 feet); beam, 18.71 meters (61 feet 10 inches); depth moulded, 12.19 meters (40 feet); mean normal draught, 7.10 meters (23 feet 3½ inches; displacement, 6,882 tons. The hull is of Siemens-Martin steel with a double cellular bottom, divided by numerous water-tight compartments and by numerous water-tight transverse bulkheads into fifteen main water-tight compartments.

The protection consists of an armored belt 2.75 meters (9 feet) in depth, of a maximum thickness of 150 millimeters (5.90 inches), extending right fore and aft, and 6 feet below the load water-line. In the central part of the ship this side armor is increased up to the upper deck, forming a redoubt, which is closed in at the two ends by armored bulkheads 120 millimeters (4.72 inches) in thickness, and extending from the lower to the upper deck. The turrets of the large guns are within the redoubt thus formed, as well as the broadside quick firers. An armored deck of turtle-back form, and of the mean thickness of 37 millimeters (1.46 inch),

runs from stem to stern. The upper deck, within the redoubt, is also covered with a plate 40 millimeters (1.58 inch) thick, while the lower deck outside the redoubt has one plate 20 millimeters (0.79 inch) thick. For the length of the engine and boiler rooms the double-bottom construction extends up the side of the ship to the underside of the armored deck, and from this point to the gun deck there is a cofferdam at each side. The nickel-steel plates used for armor were manufactured by the Società degli Alti Forni Fonderie e Acciaierie at Terni, with a special process of cementation similar to Harvey's.

The armament of the *General San Martin* is as follows: Four guns of 203 millimeters (8 inches) caliber, situated in pairs in two revolving armored turrets, 102 millimeters (4 inches) thick, at the end of the redoubt, with the very wide angle of training of 274 degrees; ten guns of 152 millimeters (6 inches) arranged in battery in the redoubt, with an arc of 110 degrees, the fore-and-aft guns being able to fire in line with the keel; six guns, 120 millimeters (4.7 inches) on the upper deck, the central weapons having an arc of 130 degrees, the bow and stern guns 155 degrees, and firing in line with the keel. Twelve guns of 57 millimeters, ten Maxim machine guns of 37 millimeters, two landing guns, 75 millimeters, two landing mitrailleuses of rifle caliber, and four torpedo tubes on the broadside on the lower deck for discharging 18-inch torpedoes. Most of the artillery was furnished by Messrs. Armstrong, of Pozzuoli, and is all according to the latest models, wire construction, single-movement, pedestal mounting with quick double electric or percussion firing. Whitehead, of Fiume, furnished the torpedo-launching tubes for firing with cordite.

The magazines are very large, the various kinds of projectiles and charges and cartridges being arranged in separate rooms. The ammunition service, studied by Messrs. Orlando with the greatest care, together with the arrangement and distribution of the projectiles, is performed by 16 vertical and inclined elevators of a special type, constructed according to the designs of Messrs. Orlando, and furnished, along with their hand and electric motors, by the Società Nazionale delle Officine di Savigliano, of Turin.

Electric motors for the service of the turrets, combined with hand and speed-regulating gears, insures rapidity in working and instant stopping.

The crew consists of 500 men and 40 officers. The Admiral's apartment includes a state-room and a dining-room. The officer's mess-room is in carved wood and inlaid in the Italian style. The ventilation of all the rooms is by a distribution of ventilating tubes and other mechanical apparatus.

The electric plant for illumination and transmission of energy for the service of the artillery and projectors consists of five compound-wound dynamos of 300 ampères and 80 volts, coupled to vertical compound tandem engines furnished by Franco Tosi, of Legnano. Two are arranged over and two under the armored deck. The dynamos are interchangeable. There are 700 lamps and four reflectors of 16 lamps for overboard illumination during coaling; five projectors of Schuckert's type with parabolic mirrors arranged as follows: One on the mast of 750 millimeters (29.5 inches) with 360 degrees range of view; four of 600 millimeters (23.62 inches) in the battery with 180 degrees range. The fore-top searchlight is to be operated from a distance by electric motors.

The propelling machinery, furnished by the Società Industriale Napoletana Hawthorn-Guppy, of Naples, consists of two sets of triple-expansion vertical engines with three inverted cylinders of 1.04 meters (42 inches), 1.610 meters (63.38 inches), and 2.360 meters (82.91 inches) diameter and 1.17 meters (46 inches) stroke. The high-pressure cylinder has a piston valve, the others ordinary slide valves, and Joy's assistant cylinders. The cylinders are all steam-jacketed. The slide motion is with double-bar links on the Stephenson system, and the starting motion includes steam and hand independent apparatus. The two main condensers, of gun-metal, have a cooling surface of 16,000 square feet. The circulation water is provided by two centrifugal pumps of 1.22 meters (48 inches) diameter, driven by independent compound engines. They have each an auxiliary air pump. The two single-acting main air pumps, with cylinders 686 millimeters (27 inches) in diameter by 533 millimeters (21.78 inches) stroke, are driven by

side levers from the intermediate cylinder crosshead. Two main Worthington feed pumps draw from hot wells or from the compartments of the double bottom fitted as fresh-water tanks. Two centrifugal ventilators of 1.22 meters (48 inches) diameter are fitted for ventilating the engine rooms.

The two propellers are of gun-metal, each with four blades, and have a diameter of 4.876 meters (16 feet) and a pitch of 7.190 meters (23 feet 7 inches).

Steam is provided by two groups of four boilers situated abaft and forward of the engines. The communication is through a tunnel fitted with water-tight doors. As in the engine compartment, there is a center-line longitudinal water-tight bulkhead, so that each pair of boilers is in a separate compartment. All the boilers are single-ended, the four forward boilers and the first two abaft the engines having a diameter of 4.74 meters (15 feet 6½ inches), with four Fox's furnaces, 1.019 meters (39 inches) diameter. The total grate surface is 72 square meters (775 square feet), and the heating surface 1,997 square meters (21,427 square feet). The steam pressure is 155 pounds to the square inch. For the forced draft every boiler is provided with an undergrate, blowing, centrifugal ventilator, while steam elevators and hydraulic ejectors perform the ash service. The two funnels have a diameter of 2.438 meters (8 feet), with a height of 22.90 meters (75 feet) from the grate level.

Four Worthington auxiliary feed pumps of 127 millimeters (4.99 inches) diameter are placed in the boiler rooms, and two of similar size for the bilge, and two of 178 millimeters (7 inches) diameter for the fire service.

There is an auxiliary boiler, 2.43 meters (8 feet) in diameter, arranged on the armored deck; it has two furnaces with a grate surface of 25 square feet, while it has a heating surface of 629 square feet, and works at 155 pounds pressure.

The bunkers are arranged on and beneath the armored deck, and have a respective capacity of 673.2 and 638.4 cubic meters, in all 1,311.66 cubic meters (about 46,300 cubic feet).

Amongst the auxiliary machinery on board is a 380-millimeter (15-inch) Worthington steam exhaust pump, two Yaryan distil-

lers, each with a capacity of 30 tons of water per 24 hours; several Downton service and fire pumps; a vertical double-cylinder engine, 300 millimeters (11.18 inches) in diameter, for the anchor service, acting independently; three large windlass heads and a central capstan; a double independent service of steam-steering engines, arranged under the armored deck in two compartments, a two-cylinder mooring winch with 228-millimeter (9-inch) cylinders, and a large workshop for repairs, the machinery being driven by electric engines. We may also note the landing gear for 152-millimeter guns, those for the torpedo maneuvering, the electric gear for transmission of the orders to the artillery, the electric gear (Molinari's system) showing the engine revolutions, all of them arranged on the conning bridge and in the armored turret.

The *General San Martin* has ten boats, of which two are steam cutters and four lifeboats, all to be worked by steam derricks and davits. There is a mooring winch provided with suitable drums for wire cable. All the gear was submitted by Messrs. Orlando to severe tests, under the survey of a commission of Argentine officers presided over by the Commander Sir Manuel José Garcia, and before by the Comodoro Martin Rivadavia, who signed the contract of this ship.

The trials of the artillery took place on February 2, 3, 4 and 5 at Spezia, under the control of the Royal Italian Navy, and with the assistance of Argentine officers, and the results proved most satisfactory. Neither the ship nor the inside fittings suffered the slightest damage during the firing of the powerful artillery, and the solidity of the construction, as well as the great military value of the ship, was thereby well tested. Equally satisfactory proved the trials of illumination, of the firing of torpedoes, and the working of the projectors, as well as those of the electric firing of the guns, which executed a simultaneous firing of eight guns, say five guns of 152 millimeters and three guns of 120 millimeters, from the same side, without causing the least damage to any part of the ship.

Three speed and engine trials were carried out under the direction of the naval architects and mechanical engineers,

Messrs. Giuseppe and Salvatore Orlando, as representatives of their firm, and of Mr. Nelson Foley, representing the firm Hawthorn Guppy. The ship was entrusted to Commander Cap. Chiodo, under the control of the Argentine Commission presided over by Commander Manuel José Garcia, who, owing to the excellent results obtained, considered these three preliminary trials as definite and conclusive.

The first six hours' natural-draft trial took place on February 8, on the following course, viz: Scoglio Ferale-Torre Guardiola, 2.20 nautical miles of the beautiful Gulf of Spezia. The mean draught of the ship was 7.155 meters, somewhat in excess of the normal.

The sea was "agitated," there being a strong north wind blowing. The result was as follows, viz:

Mean speed, knots,	18.071
Maximum speed, knots,	18.439
Mean revolutions,	93.87
Maximum revolutions,	95.5
Mean indicated horse power,	8,285.8
Maximum indicated horse power,	8,832.
Slip of propellers, per cent.,	17.
Coal consumption per indicated horse power (0.83 kilograms), pounds,	1.77
Mean pressure in the boilers, pounds,	144.2
Mean pressure at the valve chests, pounds,	139.86

The second trial at progressive speeds, from 10 to 18 knots, took place on the course Scuola-Tino (1.005 nautical miles), off the Gulf of Spezia, on February 16, and served to trace the real speed curve and to ascertain the slip of the screws. The mean draught of 7.131 meters was also in that instance in excess of the normal one, while a slight west-south-west wind kept the sea rather rough. The depth of water, which is shallow, evidently influenced the speed adversely. The results obtained were from

10.021 knots up to 18.17 knots.
48.3 revolutions up to 92.84 revolutions.
1,124.47 I.H.P. up to 8,285 indicated horse power.
Slip, 10 to 17 per cent.

In the two hours' forced-draft trial of March 22 on the original course of 2.2 miles—with a mean draught of 7.12 meters—the mean speed of 19.68 knots and the maximum speed of 20.06 knots was obtained with 104 revolutions and 12,436.5 indicated horse power. The air pressure was on the average 25.6 millimeters (1 inch) of water, while the contract permitted 40 millimeters (1.6 inches). Not the slightest damage occurred either to the engines or the boilers, which maintained the almost constant pressure of 148 pounds. It is noteworthy that during the trial the regulating valve maintained the same opening, and that among the steam jackets, only the high-pressure one was supplied with steam. There was no serious vibration, and all went on, as in the preceding trials, with the greatest regularity. In consequence of such good results, the Argentine Commission expressed to Messrs. Orlando their highest satisfaction. The designs of the hull are by Mr. Masdea, inspector of the Royal Italian Navy. The modifications relating to the armament were studied and executed by Messrs. Orlando, agreeably to the wishes expressed by Comodoro Martin Rivadavia, of the Argentine Navy. In the same dockyard at Leghorn is now in an advanced stage of armament another armored cruiser, the *General Belgrano*, also for the Argentine Government.—"Engineering."

BRAZIL.

Marshal Deodoro.—The Brazilian Government is having constructed at the Forges et Chantiers de la Seyne this vessel and an exactly similar one, called the *Marshal Floriano*. They are coast defense vessels of moderate size, made necessary on account of the limited draught of water in the Brazilian rivers. The general arrangement of these vessels comprises a well defended central structure, forward and abaft of which are the principal turrets covering an open deck. There is a rounded stern, and the bow at the water line is in the form of a slight cut water, forming a ram. There are two signal masts and one funnel, the latter in the center of the vessel. Length between perpendiculars, 268 feet; beam, maximum, 47.8 feet; draught, 13.1 feet, and displacement, 3,162 tons.

The vessel has two complete decks, of which one is armored, and the spar deck on the central citadel.

The armament consists of—

First. Two Armstrong 9.6-inch guns in closed turrets forward and abaft the central citadel, and having a horizontal train of 250 degrees. These turrets are driven by electricity or hand power. The turret armor consists of steel plates 8 inches thick upon a double backing of steel plates .8 of an inch thick. They turn above a fixed armored ring 7.2 inches thick, through which the ammunition is raised to the turret. The ammunition hoists are electrical.

Second. Four 4.7-inch guns distributed in four barbettes on the upper deck, two of which are abaft the forward turret and two forward of the after turret, on the sides of the vessel. The train of these guns is 110 degrees, and they are protected by armor plates 2 inches thick secured to plates .8 inch thick. The guns are fitted with circular shields intended to fill the gun port in every position.

Third. Two 6-inch mortars in the midship line of the vessel at the forward and after ends of the spar deck.

Fourth. Four 57-millimeter guns of 70 calibers on the spar deck, two forward and two aft, above the barbettes of the 4.7-inch guns whose armor serves as a seating for their carriages.

Fifth. Two 37-millimeter guns upon the forward bridge and two machine guns also upon the spar deck. There are two submarine torpedoes.

The armor, besides that around the guns, consists of an armored belt 6 feet wide, whose upper edge is about 2 feet above the water line, and the lower edge about 4 feet below. The plates forming this belt are of almost trapezoidal section, and amidships are 14 inches thick at the upper edge and 6 inches at the lower edge. The thickness decreases towards the ends of the vessel. The armored deck extends from one end to the other of the vessel, with a thickness varying from 1 to 1.4 inches. The openings in this deck are protected by coamings 4 inches thick. The conning tower on the bridge is 4 inches thick.

The propelling machinery consists of two triple-expansion

engines, each driving a four-bladed bronze screw. The valve gear is of the Stephenson link type. The maximum power is expected to be 3,400 I.H.P., supplied by eight Lagrafel-D'Allest boilers, working at a pressure of 215 pounds. The circulating pumps are independent and driven by tandem compound engines. The feed pumps are of the Thirion type.

There are four dynamos made by Sautter-Harlé. They are all interchangeable, and any one is sufficient for normal duty, that is to say, the lighting, and running of three ventilators.

The ammunition hoists for the 9.6 and 4.7-inch guns are worked by electricity, as well as the turret-turning gear for the 9.6 inch guns.

Wood has been excluded from the building of these vessels as far as possible. This has been carried so far that all the bulkheads in the quarters, and even the furniture, are of metal.

The double bottom is fitted for water ballast.

The speed of these vessels is expected to be 14 knots with natural draft.

The *Deodoro* was launched at La Seyne on the 18th of June.

CHILE.

O'Higgins.—The first-class cruiser *O'Higgins*, has recently been completed by Messrs. Sir W. G. Armstrong, Whitworth & Co., to the order of the Chilian Government. She is in many ways a most remarkable vessel, combining high speed with a powerful and thoroughly protected armament, an armor belt over two thirds of her length, and a large coal supply.

The following are a few of the most important particulars of the *O'Higgins:* Length between perpendiculars, 412 feet; breadth, extreme, 62 feet 9 inches; mean draught, 22 feet; displacement, 8,500 tons. Her armament includes four 8-inch quick-firing guns mounted separately in four barbettes of 6-inch armor, with gun-houses of armor 7 inches to 5 inches in thickness; three of these are placed forward with direct-ahead fire, and one aft firing direct astern; ten 6-inch quick-firing guns, four of which are placed on the upper deck in gun-houses made of armor 6 inches to 5 inches thick, two direct-firing astern; the other six 6-inch guns, are

mounted on the main deck in casemates, whose fronts are of 6-inch armor and the backs of 5 inches; two of the 6 inch casemate guns fire right ahead, and two right astern in line of keel.

In addition to the above main armament, there are four 4.7-inch quick-firing guns mounted, two forward and two aft, on the shelter bridges, ten 12-pounder quick firers, ten 6-pounders, and four machine guns carried in the tops.

The direct-ahead fire of the *O'Higgins*—besides the guns of smaller caliber—includes three 8-inch quick-firers, two 6-inch quick-firers, and two 4.7-inch quick-firers; the direct-astern fire is one 8-inch, four 6-inch and two 4.7-inch; and on the gunnery trials these groups of seven big guns were all fired simultaneously by an electric discharge in line of keel, so as to thoroughly test the structure of the vessel, the only damage resulting being a broken marble slab in the Admiral's cabin and a little glass. The broadside discharge includes three 8-inch, five 6-inch, two 4.7-inch, five 12-pounders, five 6-pounders, and machine guns. There are also two under-water broadside torpedo tubes, and a tube above water in the stern.

The vessel is thoroughly equipped in every particular, and the internal fittings are of an unusually elaborate and luxurious character. The *O'Higgins* is sheathed with wood and coppered, the advantage of this feature being especially brought into notice by the fact that all her speed trials were carried through successfully, the vessel having never been into dock since her launch.

The armor belt of the *O'Higgins* is 7 feet deep, of 7-inch Harveyed nickel armor, tapered to 5 inches at the extreme ends, and completed by transverse bulkheads, while a curved protective deck slopes down at the sides to meet the lower edge of the armor, which it thus supports; its thickness is from 1½ inches to 2 inches.

The machinery of the *O'Higgins* has been supplied by Messrs. Humphreys, Tenant and Co., and she is provided with 30 Belleville boilers, with a maximum of 16,000 horse power, with open stokeholds. The steam trials were made during April; on April 20 and 21 she steamed continuously for 24 hours, the engines developing over 10,000 indicated horse power during the whole

period, and the speed realized during the 24 hours never falling below 19 knots. At the end of the 24 hours, turning experiments were made, and, with both engines going full speed ahead, it was found that she could reverse her direction in 2 minutes 6 seconds, the tactical diameter being 1,540 feet, and the diameter of the complete circle 1,320 feet; these measurements being equal respectively to 3.4 times and 2.9 times the underwater length of the vessel.

On April 26 she went through her six hours' full-speed natural-draft trial, during which six consecutive runs were made on the measured mile course, with and against the tide, the mean speed on the six runs being 21.52 knots, the mean of the last four runs giving 21.7 knots. The machinery worked without the least hitch throughout the twenty-four hours' and six hours' trial, and gave the greatest satisfaction to all concerned. Both speed trials were run with the vessel at her mean load draught of 22 feet, at which she carries all weights, including ammunition, provisions, fresh water and stores, and 700 tons of coal. After the six hours' speed trial the gun-firing trials alluded to above were successfully completed.

Owing to illness, neither Sir E. J. Reid, the technical adviser of the Chilian Government, nor Mr. Philip Watts, the designer of the *O'Higgins*, were able to attend the trials; Messrs. Armstrong were represented by Mr. Saxton Noble, and Admiral Uribe, chief of the Chilian Commission, was present, with Captain Nuñioz Hurtado and numerous Chilian officers. It should be mentioned that, owing to a strike of some of the firemen engaged for the trials by Messrs. Humphreys, about 150 Chilian stokers, who have come with the crew to take over the *O'Higgins*, were employed on both trials, and, though they were quite unused to the Belleville boilers, no difficulty was experienced.—"Engineering."

General Baquedano.—At the works of the Armstrong Company, on the 5th of July, a sheathed, single-screw training ship, *General Baquedano*, built for the Chilian Navy, was launched. The principal dimensions are: Length, 240 feet; breadth, 45 feet 9 inches; draught, mean, 18 feet; displacement in tons, 2,500.

Armament: Four 4.7-inch quick-firing guns, two 12 pounder quick-firing guns, two 6 pounder quick-firing guns, two Maxims, and one 18-inch torpedo tube. Speed, 12 knots with 1,500 I.H.P. and open stokeholds.

ENGLAND.

H. M. S. Albion.—The battleship *Albion*, the launch of which, on June 21, was attended by a terrible catastrophe, is a vessel of the *Canopus* class which has been built by the Thames Iron Works and Shipbuilding Company, at Blackwall, to the order of the Government. Like others of her class, she is 390 feet long between perpendiculars, 74 feet wide, and will have a draught of water of 26 feet, at which her calculated displacement is nearly 13,000 tons. The order for the *Albion* and her sister vessels was given out in July, 1896. The other ships of the class originally ordered are the *Canopus*, built at Portsmouth, the *Goliath* at Chatham, the *Ocean* at Devonport, and the *Glory* at Laird's, Birkenhead. A sixth ship, the *Vengeance*, was added to the class after the Navy Estimates for 1897 had been first put forward, the cost of her construction for the year being included in an additional half million asked for when the Shipbuilding Vote came on in the House somewhat late in the session. The last-named vessel has been put out to contract with Messrs. Vickers, Sons, and Maxim, at their newly-acquired yard, once the property of the Barrow Shipbuilding Company.

According to the official programme the *Albion* was not to have been launched before July, but circumstances which have been considered of sufficient importance by the Admiralty have hastened the event. As a consequence, the ship is in a very unfinished state. Little of the armor is in place, and the casemates are mostly not in position. The belt armor is of 6-inch Harveyed steel and extends over a length of 196 feet, protecting the side for 5 feet below and 9 feet above the water line. It is backed by 4 inches of teak and has also two thicknesses of ½-inch plating. At the ends of this protected length are athwartship bulkheads, also of Harveyed steel plates 12 inches, 10 inches and 8 inches in thickness. These join the two sides of the belt

and connect also with the two barbettes which form positions for the principal armament.

The arrangement of the armored deck is similar to that now adopted by the Admiralty for battleships, the deck being joined at its outer edges to the bottom of the belt, but having transversely sufficient rise to bring the central part 2 feet 6 inches above the water line. The main and middle decks are also protected by plates ½ inch and 1 inch thick.

The 6-inch guns are mounted in casemates in the way now usual for guns of this nature, having 6-inch armor at the sides; whilst inboard they are partitioned off by a double thickness of 1-inch plating. The forward and after casemates are sponsoned out sufficiently to allow a line of fire directly ahead in the case of the forward guns, and directly astern in the case of the after guns, the angle commanded in both instances being 120 degrees. The barbettes are armored on the upper parts with 12-inch Harveyed steel plates, the lower tiers of plates, which are behind other armor, being 6 inches thick. For protection of the guns in the barbettes there are 8-inch Harveyed steel shields. The ends of the ships of this design are partially protected by 2-inch nickel-steel plates being worked outside the skin plating from the forward bulkhead to the stem, and from the after bulkhead to the stern. This forms what is practically a continuation of the belt of extended area.

The main armament consists of four 12-inch wire-wound guns of 46 tons each. These will be mounted in pairs in the barbettes upon turntables, and have the now usual "all-round" loading arrangements. There are twelve 6-inch quick-firing guns placed each in a separate casemate, eight being on the main deck and four on the upper deck. There are ten 12-pounders, six being on the upper deck amidships and between the two 6-inch guns on each broadside, whilst four are placed on the main deck, two right forward and two right aft. There are also six 3-pounder Hotchkiss guns, these being distributed between the two military tops on each of the two masts. There are also two 12-pounder guns for boat and landing purposes, eight .45-inch Maxim automatic guns, and six howitzers. The torpedo tubes are submerged, and are four in number, two being well forward and two aft.

They are for 18-inch torpedoes, of which fourteen will be carried for firing from the ship, whilst five 14-inch torpedoes will be supplied to be launched from the dropping gear fixed to the steam pinnaces.

The machinery is being made by Messrs. Maudslay, Sons, and Field, of Lambeth. The twin-screw engines are of the usual triple-expansion type, the cylinders being 30 inches, 49 inches, and 80 inches in diameter, the stroke being 4 feet 3 inches. At 108 revolutions per minute, the horse power developed is estimated to be 13,500, which corresponds to a speed of 18½ knots. The high and intermediate-pressure cylinders have piston valves, the low-pressure cylinder having flat slide valves. All are driven by double eccentrics and double-bar links. Each cylinder is supported by four columns of H-section standing on cast-steel main bearing frames. The same contractors are supplying a good deal of the auxiliary machinery, including feed pumps, compressing machinery for supplying air jets to the furnaces and compressed air for other purposes, hot-well pumps, fire and bilge pumps, fans, air compressors, electric-light engines, steering engines, etc. The boilers are of the Belleville type, having economizers, as in the *Diadem's* boilers. It may be remarked that these are the first British battleships in which it has been decided to put Belleville boilers. There are twenty of these boilers, but only two chimneys. The boilers are arranged in three groups and are fired fore and aft. The boiler pressure is to be 300 pounds per square inch, but this will be reduced to 250 pounds at the engines by the reducing valves usual with Belleville boilers. The total heating surface will be 24,155 square feet for the large tubes of the boilers proper, and 11,560 square feet for the smaller tubes in the economizers. The total weight of main and of auxiliary machinery, with water in boilers, etc., is estimated at 1,290 tons.

It will be seen from the above that the *Albion* is not so powerful a ship on paper as the vessels of the preceding class, of which the *Magnificent* was the first launched. In the first place, she is about 2,000 tons less displacement, and her armored belt is not so thick by 3 inches, is over 100 feet shorter, and 1 foot less depth. It is said, however, that improvements in the manufac-

ture of armor plating have resulted in giving as great a resistance for the modern 6-inch belt as was possessed by the 9-inch armor of the *Magnificent*, although, it must be remembered, the latter was of Harveyed steel. The new ship has, however, the additional protection at the ends, which will be good at anything like close range against light projectiles only. The barbettes of the *Canopus* class have also 12-inch armor in place of the 14 inches of the *Magnificent*. If we compare the thickness of armor with that of the *Royal Sovereign*, we find a still greater disparity, for the latter ship had an 18-inch belt, but that was not Harveyed steel plating. The four guns of the main armament are of the same weight in both the *Magnificent* class and the *Canopus* class, a fact which must be put to the credit of a smaller ship; and the same thing may be said of the 6-inch quick-firers and their casemates, of which twelve are provided in each design; but the lighter guns are more numerous in the older design, there being sixteen 12-pounders.

The mounting of the 6-inch guns at either end of the battery, to which reference has already been made, gives the *Canopus* class a very powerful bow or stern attack. The two 46-ton guns in each barbette have been estimated to discharge, within the space of five minutes, eight rounds, the energy of which would be 264,160 foot-tons. The four 6-inch quick-firers at the ends of the battery, on the upper and main decks—which, as stated, can be trained in a line parallel to the keel—would fire 25 rounds each in the same time, and that would add a striking energy of 335,600 foot-tons to the total, so that two 6-inch guns are more than equal in this respect to one of the guns of the main armament. The two 12-pounder quick-firers which could be brought to bear right ahead or astern would fire about 75 rounds each in the five minutes, and that would add another 63,450 foot-tons. This would bring the total energy of fire right ahead or right astern to 663,210 foot-tons, which is considerably in excess of the *Magnificent's* power of attack in the same direct lines. Naturally, the broadside fire would not show the same preponderance for the later design, as the advantage is obtained only in the line of fire directly ahead or astern by the sponsoned mounting of the four

6-inch guns at each end of the battery. The weight of the 12-inch projectile is 850 pounds, and that of the 6-inch projectile is 100 pounds.

In regard to engine power, the *Canopus* class have the advantage, their estimated power being 13,500 I.H.P., which should be compared with the originally estimated 12,000 power with forced draft of the *Magnificent*, the computed speed of the latter having been 17½ knots. The *Canopus* class are therefore put down at a knot faster, and we believe 1,000 extra H.P. was added to the legend when, after the original designs were got out, it was decided to compound the Belleville boilers, or fit them with what are known as economizers. The full coal capacity of the *Magnificent* is 1,800 tons, or 100 tons less than that of the new ships.

Naturally it is not possible to make an accurate comparison of different designs without having knowledge of all the elements, and this complete information is known only at the Admiralty. We may, perhaps, safely conclude that no great sacrifice has been made of essential military features to secure the advantages that the new ships undoubtedly possess. Sir William White, therefore, appears to have even surpassed his former efforts, and Sir John Durston is likewise to be congratulated, for the additional power attained is one of the conspicuous features of the class.

There is one other feature of design to which reference may be made. Profiting by a melancholy experience, the style of ram bow applied to recent vessels has been framed on new lines. It is brought nearer the surface than was usual formerly, and is altogether of a more substantial nature, having more the appearance of the fore end of a bottle-nosed whale than the "spur" of the earlier ironclads. Being near the surface, and of such substantial proportions would lead, one would think, to an appreciable addition to the wave-making resistance; but, on the other hand, the hole that it would make in an adversary would put the matter of further combat beyond the pale of reckoning. This massive ram has additional support to that formerly given in designs by the 2-inch bow armor of nickel steel, web frames,

the armored deck, and a platform deck associated with a stiffening of steel 2 inches thick.

It is an interesting fact, which has been brought to our notice by Mr. J. M. Macrow, the naval architect who has for so many years been the chief professional officer at the Thames Iron Works, that on the slip from which the *Albion* was launched last Tuesday, the first iron war vessel built for the Royal Navy was constructed fifty years ago. This was the *Vulcan*, a sister ship to the *Simoon* and the *Megæra*. She was designed as a steam frigate, but when well advanced it was determined that iron was not a suitable material to withstand shot and shell, so the *Vulcan* was transformed into a trooper. In the present day engineers may be apt to question the wisdom of the committee of naval officers who arrived at this decision, but it must be remembered that there is a vast difference between the iron skins of those days and the Harveyed plates of the *Canopus* class, or even the ordinary steel plates of to-day. As between wood and the iron construction of that era the naval officers had common sense on their side. The *Vulcan* was originally engined by Rennies, having four-cylinder engines 49½ inches in diameter, the boiler pressure being 8 pounds per square inch and the horse power 793, the speed being 9½ knots. These engines were replaced by a pair of two-cylinder engines by Maudslay's, the diameter of each being 64 inches, the steam pressure 10 pounds, and the horse power 857, but the speed remained much as before, in spite of these advances.—"Engineering."

H. M. S. Europa, a first class protected cruiser of 11,000 tons, built by the Clydebank Shipbuilding and Engineering Company, Limited, Clydebank, has recently completed her official steam trials in the English Channel, of which the results are given further on. The ship, which belongs to the *Diadem* class, of which eight have been ordered, has already been described in "Engineering." She is 435 feet long, 69 feet 6 inches extreme breadth, and at 25 feet 3 inches draught displaces 11,000 tons. She has a protected deck right fore and aft, and her guns are all protected. Her armament includes sixteen 6-inch quick-firing guns; fourteen 12-pounder quick-firing guns; three 3-pounder

quick-firing guns; eight machine guns; and two submerged torpedo-launching tubes.

The main engines are of the four-cylinder triple-expansion type. Each of the two sets is designed to develop 8,250 indicated horse power, giving a combined indicated horse power of 16,500. Steam is supplied by water-tube boilers of the Belleville type. The safety valves on the boilers are loaded to a pressure of 300 pounds per square inch, this pressure being reduced to 250 pounds at the engines by means of a reducing valve placed at the forward end of each engine room. Each set of engines is placed in a separate engine room, divided by a longitudinal water-tight bulkhead, which extends the whole length of the machinery space, and each engine room is, in all respects, exactly similar, and entirely independent of the other.

The diameters of the high and intermediate-pressure cylinders are 34 inches and 55½ inches respectively, while the diameter of each of the low-pressure cylinders is 64 inches, all having a stroke of 4 feet. The high and intermediate-pressure cylinders are fitted with piston valves of the inside type, having approved adjustable packing rings, while the low-pressure cylinders are fitted with treble-ported, flat side valves on their sides, having a special type of relief frame to remove the steam pressure, and the weight of all valves is suitably balanced in order to reduce the strain on the valve gear as far as possible. The cylinders, which are entirely independent castings, are bolted together to provide sufficient longitudinal stiffness; and to further increase their stability in the event of ramming, &c., strong struts are fitted between the high-pressure cylinder and the forward structure of the vessel, as well as transversely between the respective cylinders in each engine room. The barrels of all the cylinders are made of special close-grained cast-iron, and are steam jacketed. The valve gear is of the double-eccentric, link-motion type, and is moved by means of a double-cylinder engine attached to one of the intermediate front columns at the level of the starting platform and beside the starting handles. Each of the reversing arms is provided with screw gear, so that the valves of each cylinder may be linked up independently.

The pistons, cylinder covers and steam-chest doors are of cast steel. The piston and connecting rods are of Siemens-Martin steel, and metallic packing has been employed for all the stuffing-box glands of the piston rods and valve spindles of the main engines, as well as for all of the auxiliary engines throughout the vessel. The crankshafts are hollow, and each consists of two interchangeable pieces, 17½ inches in diameter at the journals and 9 inches in internal diameter; the crank arms are cut away as much as possible for lightness; the thrust shaft and propeller shafting are also hollow, the shafting being 16¼ inches in diameter inboard, and 17½ inches in diameter outside the ship.

The propellers are three-bladed, working inwards, and are 17 feet 6 inches in diameter. The bosses are of gun-metal, and the blades are of manganese-bronze, this material permitting a considerable reduction of section to be made on account of its superior strength in comparison with gun-metal for such purposes, and consequently a corresponding increase of the efficiency of the propellers is anticipated. The blades are secured to the bosses by large forged naval-bronze pins. Tail pieces and guards for preventing eddies either forward or aft of the propeller have been fitted in accordance with the usual Admiralty practice.

The condensers are of cast brass, having a total cooling surface of 17,500 square feet. The steam is condensed outside the tubes, which are ⅝-inch in external diameter by .05-inch thick, the circulating water passing through them. The water is supplied by four large Allen's circulating pumps, each being driven by an independent engine. Each pump is large enough to supply sufficient condensing water for full-power working. The pumps with steam of 200 pounds pressure, are each capable of discharging per hour 1,200 tons of water from the bilge. The engines driving them may exhaust into the atmosphere, and work at a speed of 300 revolutions per minute. The exhaust steam from the whole of the auxiliary machinery in the ship is led into the auxiliary exhaust pipes, which are connected both with the atmosphere, by the auxiliary exhaust pipe carried up the funnel, and with the respective auxiliary condensers in either engine room. Each of these condensers has its own air and aux-

iliary circulating pump, entirely independent of those for the main condenser, and these are driven by independent engines. The combined cooling surface of these two auxiliary condensers is 2,200 square feet, and their tube casings, like those of the main condenser, are of cast brass. Messrs. W. H. Allen and Co. supplied the pumping machinery in connection with them.

Besides the auxiliary engines already noticed, a double-cylinder turning engine is conveniently placed above the starting platform on one of the aft columns which support each of the aft low-pressure cylinders, for the purpose of turning the engines. This is effected by a set of compound worm gearing, the wormwheels having machine-cut gun-metal teeth, the main worms being of manganese-bronze. These engines are capable of turning the main engines completely round in eight minutes with a steam pressure of 200 pounds, and a hand gear has also been arranged for the same purpose.

There are also several auxiliary engines in the main engine room, to which reference may be made here, and before we enter upon a description of the boilers. The distilling machinery consists of two sets of Weir's evaporators and distilling condensers, with pumps complete, one set fitted in each engine room. There are two steering engines of Caldwell and Co.'s manufacture fitted against the after bulkhead of the engine rooms. There are also four large vertical fire and bilge pumps of the duplex type, and two large hotwell pumps of the same type. These latter pumps take the water from the hotwell tanks, and discharge through the filters to the feed tanks. In each of the engine rooms a steam fan, 6 feet in diameter, has been placed for the purpose of delivering fresh air to the engine room. In addition to the fans in the engine room there are eight fans in the boiler rooms, two in each of the four stokeholds; these are 7 feet 6 inches in diameter, and are double-breasted, with a diaphragm plate in the middle, and they may be regulated from either the fan platforms or the stokehold floors. The discharge apertures and trunks of these fans have been arranged to insure a uniform supply of air throughout, and in the event of the boiler rooms being closed, these can maintain an ample supply of air to all the furnaces. There are

also four ship-ventilating fans, two forward and two aft of the machinery spaces, with the necessary air trunks and distributing pipes, thereby forming an efficient means of ventilating the whole of the remainder of the ship.

The electric-light machinery for generating the current for internal lighting, search lights, &c., consists of three large sets of condensing engines and dynamos. The engines are of the open-front compound type, mounted on the same bedplate, and coupled direct to dynamos, which are of the direct-current type, self-regulating, and each capable of maintaining on continuous running, 600 ampères with an electro-motive force of 80 volts at 300 revolutions per minute. One of these sets is placed in a compartment adjacent to the main engine room and under the protective deck, the other two sets being placed one in each engine room.

The air-compressing machinery for charging the torpedoes consists of two complete sets of air-compressing engines and pumps, and four sets of air-reservoir tubes, with separators and charging columns. Two engines are placed in the forward part of the vessel. Each has three air pumps of large size, and all the parts of these engines, as well as of all the other auxiliary engines throughout, are designed to work at the full boiler pressure of 300 pounds per square inch.

The remaining pieces of auxiliary machinery may now be briefly noticed. Among the more important are the boat-hoisting winches, which are two in number. The barrels are each arranged to take about 240 feet of wire rope capable of lifting 17 tons. There are two coal-hoisting winches situated on the upper deck. Eight double-cylinder ash-hoisting engines, with brake apparatus and automatic stop gear, are also fitted for removing ashes from each of the stoking platforms and discharging them overboard. The engineers' workshop is fitted with a double-cylinder engine, and a complete complement of machine tools.

In the *Europa* there are in all thirty Belleville boilers, of the economizer type, in four separate water-tight compartments. In each of the after and second aft boiler rooms there are eight boilers

of eight elements, each boiler having an economizer of six elements. In the second forward boiler room there are two boilers of eight elements and six boilers of seven elements, and, as in the after boiler room, each has an economizer of six elements. In the forward boiler room there are four boilers of nine elements, and two boilers of eight elements; the nine-element boilers have economizers of seven elements, and the two eight-element boilers have six-element economizers. Each boiler element consists of seven pairs of tubes screwed in junction boxes of malleable cast-iron. The tubes are $4\frac{1}{2}$ inches in external diameter, and are of cold solid-drawn steel. The economizer elements are similar to the main elements, with the exception that the tubes are $2\frac{3}{4}$ inches in diameter. The heating surface of the boilers is 29,620 square feet, and the economizers have a surface of 10,980 square feet, making a total heating surface of 40,600 square feet, and the grate surface is 1,450 square feet.

The feed arrangements for supplying the boilers have been most carefully worked out, and every precaution has been taken to insure the efficiency of the system against any contingency. The arrangement comprises a main and auxiliary system of pumps and pipes, which are separate and independent of each other. The main feed system consists of four double-acting pumps made by Messrs. G. and J. Weir, one being placed in each boiler room. These pumps draw by independent pipes from the feed tanks and deliver by branch pipes to the feed regulators attached to the boilers. The four pumps of the auxiliary feed system, likewise of Weir's manufacture, are placed one in each compartment. These auxiliary pumps are also connected to the main feed tanks by independent pipes, and in addition have separate connections to the reserve fresh-water tanks and the sea, and each discharges to the feed regulators in connection with the boilers. The main steam supply is conveyed by four lines of steel steam pipes, two lines being arranged on each side of the ship, and these are each entirely independent of the other, as are also the connecting pipes from the boilers of each of these lines. Any boiler may, therefore, be cut off from the system without interfering with the performance of the others in the compartment, as may also any

compartment from which one of these main steam pipes lead, without affecting the efficiency of the other compartment. Any group of boilers may supply steam to any of the engines.

The *Europa*, on June 1st, began the first thirty hours' official trial. Everything worked satisfactorily from start to finish. The mean results attained were 3,302 indicated horse power, the mean revolutions being 65.4 per minute, while the coal consumption was 2.2 pounds per indicated horse power per hour. The *Europa* was run four times over the measured mile at Stokes Bay at the top of the tide on the 1st June, to determine the speed for the 3,300 indicated horse power, which gave a mean speed of 12.76 knots.

On Friday forenoon, the 3d June, she commenced her second thirty hours' trial. It was 12,510 indicated horse power, or 75 per cent. of the full power, and, according to the design, this result should, without effort, be maintained under any condition as long as there is coal in the bunker. Thirty hours is a sufficiently long time for any defect to discover itself; so that, the *Europa* having passed through the ordeal for that period, there is every confidence in anticipating that she can do it as long as her coal lasts. Throughout the thirty hours everything worked satisfactorily, and the mean power was 12,739, with a mean of 103.8 revolutions. The speed of the ship, tested over the Admiralty measured course of 23 sea miles or so outside Plymouth Sound, was 19½ knots; so that in the thirty hours the *Europa* traveled some 600 sea miles, and during that time the coal consumption was at the rate of 1.9 pounds per indicated horse power per hour. As usual, hourly records were taken of the performance of the engines throughout the thirty hours' trial.

The final results, as made up at the close of the trial, showed that the mean boiler pressure was 265 pounds per square inch, and here it may be said that all the thirty steam generators were used. The steam pressure was reduced to 250 pounds at the engines by the usual valves. The links were set for a cut-off equal to about 49 per cent. of the stroke, and they were scarcely ever touched during the progress of the long trial. The mean revolutions of the starboard engine were 103.9 per minute, showing

a mean of 6,485 indicated horse power; while the port engine ran at 103.7 revolutions, showing a mean of 6,254 indicated horse power. In the case of the starboard engine the high-pressure cylinder indicated 2,151 horse power; intermediate, 1,927 horse power; the one low-pressure, 1,184 horse power; the other, 1,223 horse power: while in the case of the port engine, the high-pressure cylinder contributed 2,022 horse power; intermediate, 1,819 horse power; one low-pressure, 1,194 horse power, and the other, 1,219 horse power. The vacuum in the case of the starboard engine was 25 inches, and in the case of the port engine 25½ inches. The mean collective power for both engines was thus 12,735 indicated horse power, with 103.8 mean revolutions. During the trials there were on board Mr. J. G. Dunlop, on behalf of the Clydebank firm; Mr. Butler for the Admiralty; Mr. G. T. Corner, for the Portsmouth Dockyard; and Mr. W. H. White, Portsmouth Reserve.

After coaling at Plymouth the *Europa* left again on Tuesday morning, June 7, for an eight hours' full power trial, in which she made two runs over the deep-sea course. She had 279 pounds of steam in her boilers, and with 113 revolutions and 17,137 indicated horse power she achieved a speed of 20.4 knots, but the mean of the eight hours gave a collective indicated horse power of 17,010. The *Diadem* at the corresponding trial, with 17,188 indicated horse power, gave a speed of 20.6 knots on the deep-sea course. The *Europa* had just completed her trial, and was off Torquay, when a thick fog fell, and she had to remain for several hours. During the night, however, the fog lifted, and she returned to Spithead.

We gave in our issue of June 10 an illustration, with complete description, of the machinery of the first-class cruiser *Europa*, built and engined by the Clydebank Engineering and Shipbuilding Company, Limited, Clydebank, and supplementing that description we now give in tabular form an analysis of the important series of trials which the cruiser has just passed through. There were, in addition to the usual contract trials, tests to determine the full capabilities of the Belleville boiler under a moderate system of forcing. There were thus five trials, three of them of thirty

EUROPA—PARTICULARS OF TRIALS.

Date of trial	June 1 and 2, 1898.	June 3 and 4, 1898.	June 7 and 8, 1898.	June 10 and 11, 1898.	June 13, 1898.
Description of trial	30-hours' coal consumption at 3,300 H. P.	30 hours at 12,500 H. P.	8 hours.	30-hours' coal consumption with 24 boilers.	4-hours' full power with 24 boilers.
Heating surface in use, square feet	13,520 10 boilers.	40,550 30 boilers.	40,550 30 boilers.	31,702 24 boilers.	31,702 24 boilers.
Grate surface in use, square feet	491	1,462	1,462	1,143	1,143
Ratio of grate to heating surface	1 : 27.53	1 : 27.73	1 : 27.73	1 : 27.73	1 : 27.73
Steam pressure in boilers	212	265	279	261	280
Air pressure in stokeholds, inches of water	.25 vacuum in smoke boxes.	...	...	.07	.45
Mean revolutions per minute	65.4	103.8	112.4	102.7	110.35
Mean I.H.P.	3,302	12,739	17,010	12,666	16,298
Coal burned per I.H.P. per hour	2.24	1.94	Not taken.	2.02	1.91
Coal burned per square foot of grate per hour	15	16.9	Not taken.	22.38	27.23
I.H.P. per square foot of grate	6.72	8.71	11.63	11.08	14.25
Heating surface per I.H.P.	4.09	3.18	2.38	2.5	1.94

The coal used was very inferior, owing to the coal strike, and had been exposed to the weather without shelter in the dockyard for a long period. The coal consumption would otherwise have been lower.

hours' duration; and yet the series of steaming trials, which also included independent speed runs, were made within the minimum possible time, which is the best suggestion that everything went well. Indeed, no warship has ever gone through such a programme in such a short time with results so satisfactory, and Sir John Durston, K.C.B., the Engineer-in-Chief of the Navy, and Mr. John G. Dunlop, the Engineering Director at Clydebank, are to be congratulated.

It will be seen that the first trial was at one-fifth full power, when 10 boilers were in use, and here 3,302 indicated horse power was got for 65.4 revolutions, while the coal consumption was 2.24 pounds per horse power hour, which is satisfactory for this low power, especially in view of the fact that the coal used throughout the trial was very inferior, owing to the Welsh coal strike, a fact which should be carefully noted when comparing results. The second trial, also of thirty hours' duration, was at about 75 per cent. of the full power, with all the boilers in use, while the third was the full-power trial, of eight hours' duration, both of which gave satisfactory results alike in respect of power and consumption. The more important trials, however, are those given in the fourth and fifth columns of the Table, when only 24 out of the 30 boilers were in use. These were extra trials undertaken at the request of the Admiralty authorities. In the one case the engines were required to develop 75 per cent. of the full power, and in the other the full power, or as much as possible. In the former case the power was got with only 0.07 inch of air pressure in the stokeholds, and with a consumption of 2.02 pounds of inferior coal. On the four hours' trial the boilers, with what used to be regarded as natural-draft conditions—an air pressure less than ½-inch—gave 14.25 indicated horse power per square foot of grate, and yet only consumed 1.91 pounds per horse power hour, although the rate of consumption was 27.23 pounds per square foot of grate per hour. This result will be regarded as very favorable, indicating, as it does, that the ships of this class have that reserve of boiler power for full speed which does not characterize all the ships of the

Navy. It shows that two or three of the boilers may be placed *hors de combat* without affecting the speed of the ship.

The vessel also ran a series of trials at progressive speeds on the measured mile at Stokes Bay and over the deep-sea course from Dodman to Rame Head. The full speed of 20½ knots was easily got with the ship at full draught. On the trial of June 13 also, the speed was tested by two runs over a 24-mile course, and showed a speed of 20.8 knots. The results confirmed those got with the *Diadem*, and added one more to the long list of successes by Sir William White, the Director of Naval Construction. In this connection reference may be made to the appointment of Mr. W. J. Luke, for several years an active member of Sir William's staff, as naval architect for the Clydebank Company. Mr. Luke, who was a distinguished student of the Naval College at Greenwich, and, later, lecturer on naval architecture, has been, as an assistant constructor, closely identified with the design of first-class cruisers and the Queen's yacht, and there is a certain appropriateness in the last ship passed through his hands being the production of the company, of whose staff he is now an important member.

Niobe.—The Table on next page gives an abstract of the results of the official contract trials of H. M. S. *Niobe*, built and engined at the Naval Construction Works of Messrs. Vickers, Sons and Maxim, Limited, at Barrow-in-Furness. The *Niobe* belongs to a class of which eight have been ordered, and the *Amphitrite*, launched July 5, from the same works, is also one of the eight. The *Diadem* and *Europa*, which have also passed through their trials, are also of the same class. There is no need to describe the ship, which is of 11,000 tons displacement; but it may be said that the engines are of the triple-expansion type with two low-pressure cylinders, and with four cranks. The high-pressure cylinder is 34 inches; the intermediate, 55½ inches; and the two low-pressures each 64 inches, with a stroke of 48 inches. There are thirty Belleville boilers, and the designed full power was 16,500 I.H.P. The contract conditions, which were easily excelled, were a trial of thirty hours' duration at ⅕ full power, a thirty hours' trial at 75 per cent. of the full power, and an eight

hours' full-power run. The results of all three trials are appended:

—	3,300 I.H.P.		12,500 I.H.P.		16,500 I.H.P.	
	Starb'd.	*Port.*	*Starb'd.*	*Port.*	*Starb'd.*	*Port.*
Mean steam in boilers	200		258		263	
Mean steam at engines	147		220		235	
Mean vacuum	28.1	28.1	27.4	27.6	26.9	27.0
Mean revolutions	70.2	70.0	107.4	107.6	118.0	117.0
Mean pressure in cylinders. H.P.	30.8	37.8	88.0	86.9	166.6	106.5
Mean pressure in cylinders. I.P.	14.6	12.8	35.4	36.5	37.7	39.3
Mean pressure in cylinders. L.P.[1]	5.4	5.5	12.8	13.3	16.8	16.4
Mean pressure in cylinders. L.P.[2]	5.1	5.0	12.2	12.8	16.0	15.9
Indicated horse power. H.P.	477	583	2,078	2,065	2,771	2,742
Indicated horse power. I.P.	603	525	2,233	2,303	2,614	2,721
Indicated horse power. L.P.[1]	299	299	1,073	1,114	1,556	1,501
Indicated horse power. L.P.[2]	280	275	1,024	1,071	1,473	1,456
Total indicated horse power	1,659	1,682	6,408	6,553	8,414	8,420
Gross total indicated horse power	3,341		12,961		16,834	
Coal per indicated horse power	1.77		1.55		1.66	
Speed by log	12.3		19.3		.....	
Speed over measured course	.....		19.27		20 507	

The coal consumption comes out most satisfactory in all three trials, and particularly in the trial at 75 per cent. full power, which is supposed to be the most economical rate of steaming for the design of engine adopted. This 1.55 pound per horse power hour, of course, includes the consumption for all the auxiliary machinery on board, without rating the power of these engines, which are usually very expensive in fuel. The engines ran during this trial, as with the others, with remarkable steadiness. The variations in the total power were confined within almost the limits of error, and during the night and morning watches the variations were between 12,997 and 13,170 indicated horse power. The revolutions continued very steady between 107 and 108. Indeed, the whole machinery worked with all the steadiness and with the little attention which characterizes the tramp steamer rather than the warship, and Sir John Durston, K.C.B., the Engineer-in-Chief of the Navy and Mr. James McKechnie, the Engineering Manager at Barrow-in-Furness, are to be congratulated on the ease with which expectations of design were fulfilled. The weather was ex-

ceptionally fine and the trials followed each other as soon as the coaling arrangements permitted. The speed on the 12,500 indicated horse power and full power trials were taken on the measured distance between Rame Head and Dodman Point.

Angler.—The electrical and torpedo trials of the *Angler*, torpedo-boat destroyer, have been successfully carried out at Chatham. The official record of the recent twelve hours' coal consumption trials is as follows: Draught of water, forward, 6 feet 1 inch, aft, 6 feet 7½ inches; speed of ship, 13.145 knots; steam pressure in boilers, 184 pounds per square inch; revolutions per minute, 159.4 starboard, 160.1 port; mean I.H.P., 221 starboard, 239 port—total 460; consumption of coal, 1.84 pounds per unit of power per hour. The total coal consumption was 10,192 pounds. The *Angler* has now completed the whole of her trials.

The *Angler* left Chatham Dockyard on the 3d of June, for the final trials of her machinery, and the results obtained were satisfactory. The mean speed obtained for six runs on the measured mile was 30.559 knots. The official results were as follows for the three hours' full-speed trial: Draught of water, forward, 5 feet 11½ inches; aft, 7 feet; mean speed of ship, 30.372 knots; steam pressure in boilers, 212 pounds per square inch; revolutions per minute, 399.4 starboard, 398.3 port; mean I.H.P., 2,910 starboard, 2,910 port—total for the two sets, 5,820. The steering, circle, stopping and starting trials were also successfully carried out. The builders were Messrs. J. I. Thornycroft and Co.

Proserpine.—The *Proserpine*, cruiser, has completed a thirty hours' coal consumption trial at half her full power. The trial began on Friday, 17th June, but, owing to thick weather, the *Proserpine* was compelled to anchor at the back of the Goodwins for some hours. Resuming when the mist cleared, the trial was completed at 4 o'clock on Sunday morning, the results being as follows: Pressure of steam in boilers, 235 pounds; air pressure, .52 inch; vacuum, 25.7 inches starboard, 26.7 inches port; revolutions—169.2 starboard, 168.3 port; indicated horse power, 3,615.1 (1,754.4 starboard, 1,860.7 port); speed, 17 knots; coal consumption, 2.16 pounds per indicated horse power per hour. The draught of water was 12 feet forward, and 15 feet 3 inches

aft. The results of the trial were considered satisfactory. The cruiser was built at Sheerness Dockyard and fitted with machinery made in Devonport Dockyard.

The *Proserpine* underwent her eight hours' natural-draft trial in the Channel on Friday, the 1st July. The results of the trial were officially reported as follows: Draught of water, 11 feet 7 inches forward, 15 feet 1 inch aft; steam in boilers, 255 pounds; air pressure, .9 inch; vacuum, 26.4 inches starboard, 25.8 inches port; revolutions, 195 starboard, 193.5 port; mean pressure in cylinders, high, 80.7 starboard, 75.3 port; intermediate, 40.7 starboard, 36.3 port; low, 17.2 starboard, 19.7 port; indicated horse power, high, 707.7 starboard, 657.8 port; intermediate, 924 starboard, 828 port; low, 1,046.5 starboard, 1,190.7 port—total indicated horse power, 5,354.7; speed, 19.7 knots. The *Proserpine* returned to Sheerness on the 5th from her forced-draft trial, which had to be abandoned during the last hour because some bearings became overheated. During the first three hours of the trial a mean of 7,396 horse power was indicated.

Furious.—The third of the series of trials of the cruiser *Furious* took place at Plymouth on the 26th April. On this occasion the trial was for eight hours at 10,000 horse power. The conditions as regards sea and weather were again favorable. The following were the mean results of the eight hours: Steam pressure at boilers, 256 pounds, reduced to 231 pounds in the starboard engine and 236 pounds in the port engine; vacuum, 28 inches starboard, 27.1 inches port; revolutions, 139.3 starboard, 142.3 port; the indicated horse power was 5,178 starboard, 5,094 port—a total of 10,272. The average speed was 20.1 knots, which was satisfactory, being slightly better than that attained by the sister ship *Arrogant*, on a similar trial a few months ago.

Highflyer.—A protected steel cruiser of the second-class, was launched on Saturday, the 4th June, from the yard of the Fairfield Shipbuilding and Engineering Company, Limited, Govan. The vessel is a sister ship to the *Hermes*, launched by the same builders on April 7, and described on page 540 of the May JOURNAL. The two cruisers represent an improvement on the *Juno* class, of which the Fairfield Company built two—the *Venus* and the *Diana*.

The dimensions of the *Highflyer* are: Length between perpendiculars, 350 feet; breadth, extreme, 54 feet; displacement, 5,600 tons. The coal capacity is normally 550 tons, but provision has been made for carrying a greater quantity if necessary. The propelling machinery will consist of two sets of triple-expansion engines fitted in separate engine rooms, each set having four inverted cylinders and four cranks. Belleville boilers will be fitted by the builders, and it is expected that the vessel will attain a speed of 20 knots.

Psyche.—A third-class cruiser, laid down on November 15 last, was launched on the 12th July, from the Devonport Dockyard. She is 300 feet long, 36 feet 6 inches beam, and 13 feet 6 inches draught; displaces 2,135 tons. She carries eight 4-inch and eight 3-pounder quick-firing guns. The machinery, also being constructed at Devonport, is designed to give 5,000 indicated horse power and 18½ knots under natural draft, and 7,000 indicated horse power and 20 knots under forced draft. She is of the *Pelorus* class, to which also the *Proserpine*, just tried, belongs.

Sylvia.—Torpedo-boat destroyer, built and engined by Messrs. Doxford and Sons, Sunderland, had a three hours' 30-knot trial of her machinery at Portsmouth on the 7th June, and, with 6,300 horse power and 382 revolutions, made a mean speed of 29.788 knots.

Conflict.—On Saturday, the 9th July, the *Conflict*, torpedo-boat destroyer, successfully carried out her official speed trials under usual Admiralty conditions. The speed obtained was 27.102 knots per hour for three hours. The *Conflict* is the third vessel of this type built by Messrs. J. Samuel White and Co., of West Cowes, Isle of Wight, the trials of the three vessels having taken place on the following dates:

	Speed—Knots.
Teazer, March 15, 1898, ...	27.111
Wizard, May 5, 1898, ...	27.164
Conflict, July 9, 1898, ...	27.102

Terrible, cruiser, Captain C. G. Robinson, arrived at Spithead on Friday morning, the 3d June, having on board the First Lord

of the Admiralty, accompanied by Captain W. H. Fawkes, his private secretary, and Mr. A. Chamberlain, M.P., who had taken passage in the vessel to Gibraltar and back. It was intended to run out at 10,000 indicated horse power, or two-fifths of her maximum horse power, and to return at three-fifths, or 15,000 indicated horse power, but the second part of the trial was abandoned. Leaving St. Catherine's at 2·30 P.M. on Wednesday, May 25th, the vessel soon attained her required power, and the mean of the run out was 10,246 indicated horse power, with 81.26 revolutions, which gave an average speed of 17 knots. The vessel reached Gibraltar at 10·30 A.M. on Saturday morning, thus making the passage in sixty-eight hours, which was an exact realization of the forecast. The coal consumption worked out at 1.89 pounds per unit of power per hour for all purposes, and this was regarded as satisfactory, few ships having achieved so economical a result at a two-fifths power run. At Gibraltar the ship coaled, but the quality of the fuel was very poor. The cruiser left Gibraltar on Monday evening, and, steaming at 15 knots, arrived as stated. No trouble of any kind was experienced with the boilers, and the most delightful weather was enjoyed on both the outward and homeward trips.

Implacable and **Formidable.**—The Lords of the Admiralty have given an order to Sir W. G. Armstrong, Whitworth and Co., of Elswick, for eight sets of hydraulic mountings for the 12-inch 46-ton breechloading guns of the new line-of-battle ships *Implacable* and *Formidable*, which are to be built, the former at Devonport and the latter at Portsmouth. For these eight sets of mountings, four of which will be supplied to each ship, the Elswick firm will be paid over £100,000. The 12-inch guns are to be a new type, and will be provided with gear for working them by hand power in the event of the hydraulic power giving out. The order for the mountings will include the fitting of all the apparatus required for working the guns from the ammunition room to the gun platform. Besides the 12-inch guns, which are to be mounted in barbettes, each vessel will be armed with twelve 6-inch quick-firing guns of a new type, mounted in armored casemates, sixteen 12-pounder and twelve 3-pounder quick-firing guns,

two 12-pounder boat's guns, eight .45-inch Maxim machine guns, and five Whitehead torpedo tubes, four of which will be submerged and one above water. It is estimated that the two vessels will cost £1,000,000 each.

Ocean.—The *Ocean*, line-of-battle ship, recently launched at Devonport is 390 feet long between perpendiculars by 74 feet beam. Her displacement is 13,000 tons, and her engines are to work up to 13,500 horse power indicated. It is expected that, with full power, she will steam at the rate of 18¼ knots per hour. The propelling machinery, of which the makers are Messrs. Hawthorn, Leslie and Co., consists of two complete sets of vertical triple-expansion engines, having cylinders 30 inches, 49 inches, and 80 inches in diameter, and a stroke of 4 feet 3 inches, in separate engine rooms, each set capable of developing 6,725 horse power, with 180 revolutions. The boilers are of the Belleville type and are twenty in number. They will be tested at 300 pounds per square inch, the steam pressure being reduced at the engines. The armament consists of four 12-inch 46-ton guns worked in two barbettes on revolving turntables; twelve 6-inch quick-firing guns mounted in armored casemates, eight on the main deck and four on the upper deck; ten 12-pounder guns, 12 cwt. each, six on the upper deck, four on the main deck, one in special mounting for field service, and one for boat service; six 3-pounder Hotchkiss quick-firing guns on recoil mountings; four Maxim machine guns and four submerged torpedo-tubes for the discharge of 18-inch torpedoes. The weight of the guns, mountings, and stores is, approximately, 1,000 tons, the cost of the guns being £68,000, and of the torpedoes and torpedo tubes, £15,000. Provision has been made for a complement of 751 officers and men. The coal capacity is 1,900 tons.

H. M. S. Amphitrite.—On July 5th the first-class protected cruiser *Amphitrite* was launched from Messrs. Vickers, Sons & Maxim's Naval Construction Works, at Barrow. Mrs. Vickers, wife of the chairman of the firm, performed the christening ceremony. The *Amphitrite* is of the *Argonaut* class, and is 435 feet between perpendiculars, but the overhanging stern and projecting ram make the length over all 463 feet. The breadth over

sheathing is 69 feet, and her moulded depth to the upper deck, 39 feet 9 inches. The mean load draught of the vessel is 25 feet 3 inches, at which draught the displacement is 11,000 tons.

The hull is constructed of Siemens-Martin steel, the heavy external framing of the bow and stern, as well as propeller brackets and the rudder frame, being of phosphor-bronze castings. The double bottom is minutely subdivided into watertight compartments. The protection consists of an armored deck of steel plating, 4 inches thick at the crown, which extends the whole length of the vessel. The coal bunkers have a capacity of over 2,000 tons. The *Amphitrite* is supplied with two under-water broadside torpedo tubes. There are in all 41 guns, and in one minute these will be capable of discharging 6,898 shots, varying in weight from 100 pounds downwards, and totaling about 7½ tons, while during the same period 3,854 pounds of powder will be used.

The propelling machinery consists of two sets of vertical, direct-acting, triple-expansion engines, each set having four cylinders working on separate cranks, the diameter of the cylinders being—high-pressure, 34 inches; intermediate, 55½ inches, and the two low-pressure, 64 inches. The collective I.H.P. is expected to be 18,000 when running at about 120 revolutions per minute with a steam pressure of 250 pounds. The boilers are of the latest Belleville type, fitted with economizers, there being 30 boilers. The total heating surface in the boilers and economizers is about 47,300 square feet, the grate surface being 1,390 square feet. The working steam pressure will be 300 pounds to the square inch, reduced to 250 pounds at the engines. She will steam 21 knots without resorting to forced draft.

Surly.—Oil fuel was tried at sea for the first time in the British Navy at Portsmouth on July 31. Some months ago the Admiralty sanctioned an experiment with the system invented by Mr. Holden, of the Great Eastern Railway, on board the *Surly*, torpedo-boat destroyer, and in the interval various trials have been carried out in one of the dockyard basins. At these the chief difficulty was to furnish a sufficient feed of oil, but this has been overcome by the provision of an overhead feed tank. There are

four boilers on the *Surly*, two of which are still retained for coal fuel, but the others have been adapted for oil. In lighting the latter series the elements of combustion are oil and coal, but as soon as a sufficient heat has been generated, bricks replace the coal and are heated from the oil spray. At the trial no difficulty was experienced in obtaining a sufficient spray, and the heat was so well maintained that at times the thermometer indicated 150 degrees Fahrenheit in the stokehold. Three runs over the measured mile in Stokes Bay were made, and while a speed of 16 knots was hoped for, the runs gave a mean of 14 knots; but as this was only a preliminary trial, the result was regarded as satisfactory. The oil used had a flash-point of 280 degrees Fahrenheit.

Wizard.—On Thursday, the 5th June, the *Wizard*, built by John Samuel White and Co., Limited, Cowes, Isle of Wight, was successfully tried in Stokes Bay under Admiralty trial conditions for this class of vessel. The speed obtained was 27.164 knots, as compared with 27.111 knots obtained on her sister vessel, the *Teazer*, a year ago. A novel feature in connection with the machinery of the *Wizard* is that the screws revolve towards the middle line of the vessel when going ahead, the only torpedo-boat destroyer constructed for the Admiralty in which this condition obtains.

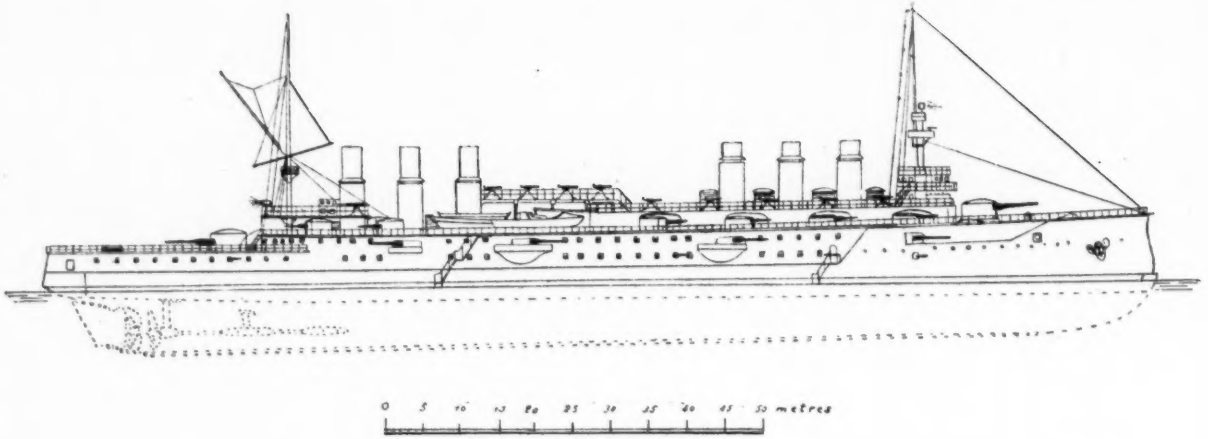
FRANCE.

Jeanne d'Arc.—The armored cruiser *Jeanne d'Arc* was begun in 1895 at Toulon. The following are the principal dimensions: Length, 475.6 feet; maximum beam, 63.63 feet; mean draught, 24.66 feet; draught aft, 26.63 feet; coal carried at this draught, 1,400 tons; displacement, 11,270 tons.

The hull is subdivided like that of the most recent battle ships. The vitals are protected by a lower armored deck; then comes a protective belt included between the two armored decks; then the superstructures above.

The protective belt recalls in a general way that of the latest English battle ships, except that the thickness of the armor is much less.

The lower armored deck is placed about at the level of the



ARMORED CRUISER "JEANNE D'ARC."

water line at the center of the vessel, while forward it descends to about 5 feet below the water line to the lower edge of the side armor. This is arranged in two strakes, a thick one, whose upper edge is 27 inches above the water line and which goes down to the lower armored deck, and a second strake, which reaches from the upper edge of the thick one to the upper armored deck. At the bow this thin strake runs clear up to the upper deck.

The lower strake has a thickness of about 6 inches at the upper edge and at the water line. The thickness gradually diminishes from the water line to the lower edge, and from the amidships to the extremities. The thickness of the upper strake is about 3 inches at its junction with the lower strake. The lower armored deck is of plating about 2 inches thick. The upper armored deck is a double thickness of plating. The side armor has a backing of teak.

The protection of the sides is completed by a cofferdam placed behind the armor, and a water-tight bulkhead installed behind this cofferdam. The space between the cofferdam and this bulkhead serves as a wing passage and permits repairs to be made to any holes in the cofferdam. It serves also as a collector for any water coming from these holes. Numerous drains provide for sending the water to the bilge.

Between these two interior water-tight bulkheads is the cellular section (*tranche cellulaire*) properly so called. Its compartments are empty, or serve for coal, water, &c. All the ammunition tubes, the funnels, and the ventilators which traverse this cellular section are protected by an annular cofferdam throughout their whole height, and by an armored coaming at their lower end.

Above the armored deck is the main deck, which runs from one extremity of the ship to the other, and the spar deck, which runs from the after turret to the bow. Above these is a small bridge around the mizzen mast, and a large bridge which runs from amidships to the forward turret. This last bridge is continued towards the stern by a small central bridge on a higher level.

Upon the main deck are installed the 5.5-inch R.F.G.; on the spar deck are the 3.9-inch guns, and upon the bridges the smaller calibers. The conning tower is situated upon the forward bridge between the fore mast and the forward turret; above it is a bridge for navigation, which carries the chart house. Under the bridges are the galleys, the water closets, &c. The wardroom officers' quarters are under the main deck at the stern, and those of the Admiral and the higher officers are under the spar deck.

The armament of the *Jeanne d'Arc* includes two 7.6-inch guns in turrets at the ends; eight 5.5-inch R.F.G., of which four are placed at the angles of the spar deck and four in sponsons on the side; ten 3.9-inch R.F.G. on the spar deck; sixteen 47-mm. R.F.G. upon the bridge; eight 37-mm., of which six are on the main deck and two in the after fighting top. There are also two torpedo tubes 18 inches in diameter.

Both the fixed and the moving parts of the turrets for the 7.6-inch cm. guns are armored. Above this armor is an armored cupola. The platform is also armored. The turrets are worked entirely by electricity.

The 5.5-inch guns are placed in casemates, the faces of which are protected by the side armor, and their sides, floors and tops by thick plates. All of these guns fire through large ports, and are further protected by shields in the shape of a U, armored on the front and the sides.

The 3.9-inch guns are protected by a moving shield which entirely covers the gunners, and, so to speak, makes a little turret. These shields are armored upon the front, sides and tops. On account of these shields, which protect the gunners from the blast of the neighboring pieces, the power of the *Jeanne d'Arc's* artillery is really formidable on all possible bearings. One 7.6-inch, four 5.5-inch, eight 3.9-inch, ten 47-mm., and four 37-mm. guns fire ahead; one 7.6-inch, four 5.5-inch, four 3.9-inch, two 47-mm., and two 37-mm., astern; two 7.6-inch, four 5.5-inch, six 3.9-inch, ten 47-mm., and four 37-mm., on either broadside. It would be difficult to devise a more ingenious disposition.

The installation of the magazines was somewhat difficult upon the *Jeanne d'Arc* on account of the great size of the motive ma-

chinery, which occupies nearly three-quarters of the length of the vessel in the central part. The magazines for the 7.6-inch guns are situated directly under the turrets, at the extremities of the motive machinery. The other magazines for the guns of medium and small caliber are under the cellular section, between the fire rooms forward of the bunkers, and above the transverse compartment for the torpedo tubes, which is situated between the forward fire room and the engine room. There is communication between all these magazines by means of the passages which run just outside of the longitudinal bulkheads of the machinery spaces. The starboard and port passages are connected at their extremities by the magazines for the 5.5-inch guns, and amidships by those placed above the torpedo compartments. A trolley permits the transportation of ammunition from one end of the vessel to the other. This plan, which was proposed in France several years ago, was adopted for the first time upon the English battle ships of the *Majestic* type. It facilitates and assures the ammunition service, since any gun can be supplied from any magazine. The projectiles for the guns of small and medium caliber are hoisted clear to the upper deck by electric hoists.

The motive machinery of the *Jeanne d'Arc* includes three engines placed in the center of the vessel between the two groups of fire rooms. The steam-generating apparatus is composed of forty-eight Guyot-Du-Temple boilers with a total grate surface of 1,636 square feet. These boilers are distributed in two groups, each having four fire rooms. Each group has three funnels, the middle one being placed at the intersection of the longitudinal and transverse bulkheads, which separate each group into four fire rooms. The three engines are placed in three water-tight compartments, one in the center and two forward. The engines and boilers were built at Indret.

The ventilation of the different compartments below the upper-armored deck is artificial, by means of electric blowers. The intakes of fresh air are placed between the funnels.

Electricity has been largely employed for working the auxiliary machinery. The turrets, the blowers, the ammunition hoists and the steering-engine valve gear are worked by elec-

tricity. Four dynamos provide light and power for the interior of the vessel, as well as the exterior lighting. There are six search lights.

The normal supply of coal has been given as 1,400 tons, but, on account of the great height of the armor belt, the vessel can carry a greater amount without sensible diminution of the protection. By filling with coal the different available compartments situated between the two armored decks, the total amount of coal carried may be 2,100 tons. With 1,400 tons the radius of action, at 10 knots, is 9,000 miles, and with 2,100 tons, 13,500 miles. The normal supply gives a radius of action of 1,250 miles at 23 knots; that is to say, full speed for fifty-five hours. With the total amount of coal available, this time could be extended to eighty-three hours.

Besides the supply of coal, the *Jeanne d'Arc* can take in a certain amount of liquid fuel in special tanks provided for this purpose, in case this method of firing should give good results on trial.

This description shows to what extent the *Jeanne d'Arc* is an interesting solution of the problem of uniting great speed, powerful artillery and efficacious protection in a vessel of moderate displacement.

It would be difficult to do more, at least as far as the plan goes, because the practical value of this solution depends in part on the way in which the boilers will behave in ordinary service. It is more than probable that they will leave nothing to be desired on the score of power, but the endurance in regular service, and, above all, the maintenance during periods of reserve may give rise to disappointment. To reduce, under pretext of economy, the displacement of vessels is a mistake, for on account of their excessive delicacy, the cost of maintenance more than counterbalances the difference between their price and that of vessels larger, and more expensive to build, but stronger, and less expensive to keep in an efficient condition.

The *Jeanne d'Arc* is a scout which possesses all the qualities necessary to seek the enemy, gain contact with him, and maintain this contact. Her great speed protects her from the attack

of destroyers, besides which, her light artillery is admirably disposed to keep them at a distance. Her protection and armament are also sufficient to permit her to fight for a short time against a battle ship. They are more powerful than those of any other cruiser actually afloat.

If we waive this particular utilization and look at the *Jeanne d'Arc* as a fighting vessel of a squadron, as a unit of a homogeneous fleet, as supposed by Admiral Fournier, for example, some defects appear, the chief of which is the insufficient protection of the armament. The casemates of the 5.5-inch guns are not sufficiently armored. Explosive shells may penetrate between the upper armored deck and the main deck by going through the side plating, and burst under the 5.5-inch and 3.9-inch guns.

These criticisms are relative, however, and when the *Jeanne d'Arc* is compared with the large cruisers of other countries which have preceded her, it is then perceived how powerful this vessel is, compared to her displacement, and the difficulty has been the combination of the different elements of this power.

The *Powerful* and *Terrible*, the largest of all the cruisers actually afloat, displace 14,200 tons, say 2,900 more than the *Jeanne d'Arc*. They make a knot less. They have no side armor. Their armament, two 9-inch, twelve 6-inch and eighteen 12-pounders, is not much heavier. They carry about the same amount of coal at normal displacement.

The English cruisers of the *Diadem* class only displace 300 tons less than the *Jeanne d'Arc*. They carry only a few tons more of coal, have no side armor, and have only a designed speed of 20.5 knots. Their armament, sixteen 6-inch and fourteen 12-pounders, is about equivalent to that of the *Jeanne d'Arc*.

The American armored cruisers, *New York* and *Brooklyn*, displace respectively, 8,200 and 9,300 tons. They are, therefore, smaller than the *Jeanne d'Arc*, but, on the other hand, they only carry 750 and 900 tons of coal.* Their speed is only 21 knots† and their side armor is only 4 inches thick, and only occupies

* This is the supply at normal draught.—Ed.

† The *Brooklyn's* speed is 22 knots.—Ed.

the height of the belt of a battle ship. If their artillery, six 8-inch and twelve 4-inch for the *New York*, eight 8-inch and twelve 5-inch for the *Brooklyn*, is superior in caliber to that of the *Jeanne d'Arc*, it is not so well arranged. Their turrets have each two guns.

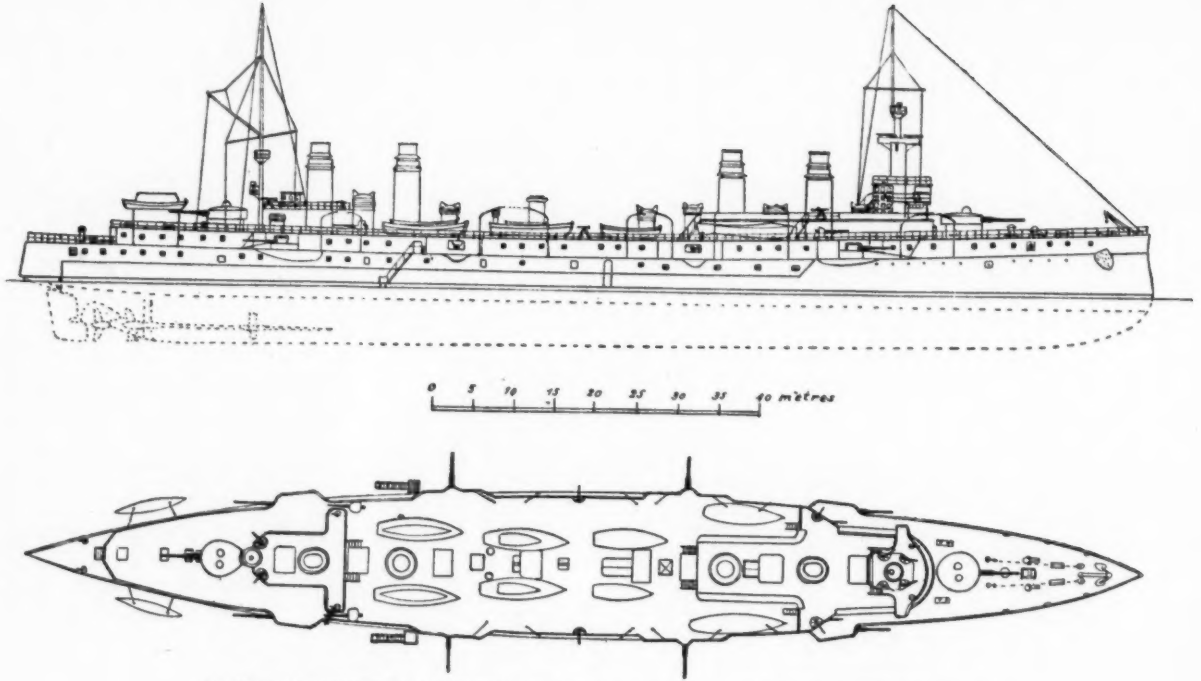
The Russian armored cruiser *Rurik* displaces 11,000 tons and only makes 18 knots. Its side armor extends only for about half the length. Its artillery, four 8-inch and sixteen 6-inch guns, is, it is true, superior to that of the *Jeanne d'Arc*, but it is not so well protected. It should be added that the *Rurik* carries 2,000 tons of coal.

Finally, the German battle ship *Leipsic*, which, strictly speaking, should be classed as an armored cruiser, displaces 10,650 tons, makes only 19 knots, and only carries 1,000 tons of coal. The armament, four 9½ and twelve 5.5-inch guns, is slightly more powerful than that of the *Jeanne d'Arc*. The side armor is also a little thicker—eight inches—but it has a belt of only moderate height above the water line.

This comparison will show that the *Jeanne d'Arc* is one of the most original and most powerful war vessels that has been built in Europe in fifty years. The designs were made by the technical experts of the Navy, under the direction of Monsieur Bertin. —Translated from "Le Yacht."

The armament of the *Jeanne d'Arc* has been modified from the original design. The present arrangement is as follows: Two 7.6-inch B.L.R. in turrets, fourteen 5.5-inch R.F.G., and twenty 47-mm. R.F.G. The object of this diminution of the number of calibers, is to secure a simplification in the service of the ammunition and the installation of the magazines, as well as a reduction in the number of the crew.

Gueydon, DuPetit-Thouars and **Montcalm.**—This trio forms a new class of armored cruisers of 9,500 tons displacement, which is a modification of the *Jeanne d'Arc* by the simple process of reducing the power and coal supply. The armament and system of protection are practically the same as for that vessel.



ARMORED CRUISERS "MONTCALM," "GUEYDON," AND "DU PETIT-THOUARS."

Length between perpendiculars, 451 feet; beam, extreme, 63.5 feet; draught, mean, 23 feet; draught, aft, 24.7 feet; displacement, 9,500 tons; coal supply at this displacement, 1,025 tons. Speed, 21 knots; I.H.P., 19,000.

As on the *Jeanne d'Arc*, the protection consists of a cellular section (*tranche cellulaire*) bounded by two armored decks and protected laterally by an armor belt in two strakes, the lower and thicker of which spans the water line, while the upper and thinner reaches to the upper armored deck. At the bow this thin strake goes up to the main deck, while at the stern it stops a little abaft the rudder post, and the strakes of the two sides are joined by a transverse armored bulkhead which descends to the hull plating. Two other transverse armored bulkheads, situated abaft the forward, and forward of the after turrets, extend from the main deck (the deck next above the upper armored deck) to the spar deck, thus protecting the 6.5-inch guns in the "'tween decks" from a raking fire.

As on the *Jeanne d'Arc*, the lower armored deck amidships is about at the water level, while forward it descends to about 5 feet below that level, to the lower edge of the thick strake of the belt. The upper armored deck is flat.

The lower strake of the belt is 6 inches thick amidships at the upper edge, which diminishes towards the lower edge and the ends of the vessel. The thickness of the upper strake is 3.8 inches amidships and diminishes towards the ends, being only 2.4 inches at the bow. The lower protective deck is 1.2 inches on the flat, and 2 inches on the slopes. The upper armored deck consists of a double thickness of plating of hardened steel.

The cellular section is arranged like that of the *Jeanne d'Arc*.

The superstructures are slightly different from those of that vessel. The spar deck is continued clear aft and the 7.6-inch turret is above this, while on the *Jeanne d'Arc* it is on the main deck. The bridges are reduced to a small one between the after funnel and the mizzen mast and one slightly larger between the forward funnel and the fore mast. This latter carries on its forward side the conning tower and pilot house. There is also a pilot house on the after bridge.

The armament includes two 7.6-inch guns in closed turrets; eight 6.5-inch R.F.G. in armored redoubts; four 3.9-inch R.F.G. on the spar deck; sixteen 47-mm. R.F.G., of which six are in the battery (between the upper armored deck and main deck), two on the spar deck amidships, four in the tops, and two on each bridge; six 37-mm. R.F.G., of which two are on the navigating bridge forward, two on the after bridge, and two on the main deck aft. There are also two under-water torpedo-tubes.

The 6.5-inch guns are placed, two forward and two aft in sponsons, so that they can fire directly ahead and astern; the four others are broadside guns. The casemates have armor plates on the outer side which are the full height of the battery; the inboard sides as well as the tops and floors have an extra thickness of hardened steel plating. The carriages have shields which reduce the port opening to a minimum. The 3.9-inch guns on the spar deck have armored shields in two parts, one fixed and the other turning with the gun.

The magazines on these vessels are arranged differently from those on the *Jeanne d'Arc*. The ammunition hoists go direct from the magazines to the main deck. Those for the 7.6-inch guns are directly below the turrets; those for the 3.9-inch, the 6.5-inch and the small guns are situated between the boiler rooms and engine rooms.

The propelling machinery consists of three triple-expansion vertical engines, each one in a separate compartment, and together they are expected to develop 19,000 I.H.P., which is expected to give a speed of 21 knots.

The *Montcalm* will have twenty Normand-Sigaudy boilers; the *DuPetit-Thouars* twenty-eight Belleville boilers, and the *Gueydon* twenty-eight Niclausse boilers.

The auxiliary engines are very numerous and include, among others, fourteen electric ammunition hoists, twelve blowers for forced draft and for ventilation below the protective deck, and three Thirion bilge pumps with an aggregate capacity of 600 tons per hour. The electric current for power and lighting is furnished by four dynamos. The 7.6-inch turrets are worked by electricity.

The radius of action at ten knots, with the normal supply of coal (1,025 tons) is 6,500 knots. If the reserve bunkers in the cellular section are filled, this distance will be raised to 10,300 knots. It is to be understood, of course, that these are theoretical figures, serving only for comparison between one ship and another. The case of the *Powerful* shows that they may not have any practical significance.

The crew of these vessels will be 562 ordinarily and 610 when they are flagships.

If we compare this type of cruiser with the *Jeanne d'Arc*, we see that the artillery of the two types is about equal. Each of them has two 7.6-inch guns. The eight 6.5-inch and the four 3.9-inch of the 9,500-ton cruisers are scarcely less powerful than the eight 5.5-inch and the ten 3.9-inch of the *Jeanne d'Arc*. The small guns of both classes are practically the same. The *Jeanne d'Arc* has the battery better arranged for ahead fire, which gives her a certain superiority when chasing. The protection is the same in both cases. In fact, the two types only differ in speed and radius of action. It has already been explained that the speed of the *Jeanne d'Arc* (23 knots) is rather high if she is to be used in squadron. She, as well as the *Montcalm*, can practically only serve as a scout. On account of both their protection and armament they need only fear battle ships, but inasmuch as at present scarcely any battle ship is faster than 18 knots, 21 knots seems a sufficient speed for the scouts. The reduction of speed in the 9,500-ton cruisers has permitted the installation of machinery and boilers (especially the latter) of a heavier and more robust type than those of the *Jeanne d'Arc*. While the *Montcalm* has indeed been fitted with torpedo-boat boilers, the *DuPetit-Thouars* has been provided with Belleville boilers, and the *Gueydon* with Niclausse boilers. The latter are considered to be more reliable from the point of view of maintenance than the torpedo-boat boilers.

In our opinion, the reduction of the radius of action in the 9,500-ton cruisers is a mistake. A great radius of action is one of the most important features of the scout, which is obliged to make long trips at high speed, and should not be compelled to

interrupt its cruise to take on coal. Finally, it should be noted that in the 9,500-ton ships the guns in the armored redoubts are insufficiently protected; just as in the *Jeanne d'Arc* there is nothing to prevent explosive shells from penetrating the battery and bursting under the redoubts.

Although we have given these criticisms, our new type of armored cruiser is excellent from many points of view, and constitutes an almost perfect scout. It was to be hoped that our navy would rest at this point instead of seeking, according to custom, to reduce in an exaggerated degree the dimensions and the displacement. If, as is to be hoped, an analogous type is to be designed, the radius of action should be increased, and, above all, a remedy should be provided for the lack of protection to the guns in the redoubt. With these two faults corrected, the type would be perfect. The *Montcalm* is building by the Forges et Chantiers de la Méditerranée at La Seyne; the *DuPetit-Thouars* by the dockyard at Toulon, and the *Gueydon* by the dockyard at Lorient.—Translated from "Le Yacht."

Suffren.—The dockyard at Brest will shortly lay down a new battle ship to be called the *Suffren*, which is an enlarged and somewhat modified *Iena*. It will be the largest and most powerful armed battle ship thus far constructed in France.

The plans of the new *Suffren* are due to Thibaudier, Directeur du materiel. The following are the principal dimensions: Length, 412 feet; beam at water line, 70 feet; beam, maximum, at 1.3 feet below the water line, 70.3 feet; mean draught, 26 feet; draught, aft, 27.5 feet; displacement, 12,728 tons.

The motive machinery will be built at Indret, and is composed of three triple-expansion vertical engines, each in a separate compartment, and driving a separate screw. The boilers will be of the Belleville type, with economizers, and arranged to burn liquid fuel in conjunction with coal. The maximum power is to be 16,200 horses, giving a speed of 18 knots.

The normal supply of combustible, coal and liquid fuel, will be 820 tons, without careful stowing, and the radius of action corresponding is estimated at 5,100 miles at 10 knots speed. With briquettes carefully stowed in the bunkers the coal supply will

be 1,150 tons, with a slight increase of displacement, and the radius of action will then be 7,000 miles at 10 knots.

The armament is composed of four 12-inch B.L.R. placed in two turrets, one at the bow and one at the stern, with an angle of fire of more than 270 degrees. The plans for the turrets have not been definitely settled, but they will be worked both by electricity and hand power, employing the latter as much as possible.

The secondary battery comprises ten 6.5-inch R.F.G., four of which will be in armored casemates, with ports at the corners upon the intermediate deck. The six others will be on the upper deck, and each one in a separate turret. There will also be eight 3.9-inch R.F.G. upon the superstructure. The light guns consist of twenty 47-mm. R.F.G., of which eight are on the main deck, eight in the tops and four upon the bridges. There will be four torpedo tubes, two of which will be submerged and two above water at the bow behind the light armor.

The side armor will extend over the whole length of the vessel, according to the method which has always been followed in France. Above this will be a light belt to protect the upper works. There will be two armored decks, corresponding to the edges of the armor belt.—"Le Yacht."

Charlemagne.—The contractors finished their preliminary trials of this battle ship in the latter part of April, finding that everything had worked very satisfactorily. They did not attempt to get the full power of 14,500 I.H.P. required by the contract, but were content with about 14,300, when everything worked well and gave assurance of the certainty of obtaining the full power. The trials were made in the Bay of Douarnenez, and gave with this horse power a mean speed of about 17.7 knots. The bottom was quite foul, and the vessel was to be docked and the bottom cleaned before the official trial at full speed.

The first official trial was to determine the coal consumption at 1,500 horse power. The central screw alone was used, giving an average number of revolutions of about 79, and a speed of 8.3 knots. The consumption was 1.38 pounds per horse power per hour.

The second in the series of official trials of the *Charlemagne*,

that at 5,000 horse power, was as successful as the first. All three engines were in use, with an average of 88 revolutions for the center screw and 94 for the side screws. The coal burned was at the rate of 10 pounds per square foot of grate per hour, during the six hours of the trial. The horse power developed was 5,170 and the corresponding speed 14 knots. The coal per horse power per hour was 1.45 pounds, bringing a premium to the contractors of 7,000 francs. A previous trial had earned them 10,000 francs on account of the consumption being only 1.38 pounds, instead of the 1.54 to 1.76 pounds allowed.

Both these trials were in good weather, and showed that the *Charlemagne* steers perfectly, as was evident from the previous trials.

On the 11th of June the third of the official trials of this vessel—that at full power, natural draft—took place in the Bay of Douarnenez in fine weather. All three engines were in use with all the boilers. The horse power was 11,460, with 119.6 as the average for the revolutions of the three screws. The mean speed was 17.25; the coal consumption was 1.63 pounds per I.H.P. per hour.

The full-power forced-draft trial occurred a few days afterward in the same locality, and also with fine weather, but somewhat foggy. The mean speed was 18.14 knots for a horse power of 15,295. The fire rooms were closed, but with ordinary doors without air locks.

The twenty-four-hour coal consumption trial, at about 9,000 horse power, occurred in the early part of July. The horse power was 9,270, and the average speed for the twenty-four hours was 16.41. The coal consumption per I.H.P., per hour, was 1.55 pounds. Some trials were made with liquid fuel, but were not entirely satisfactory, and some details of the apparatus are to be modified. The vessel is now in the dockyard for the examination of the machinery after the trials, and when the final acceptance trial after the examination of the machinery is made, the trials with liquid fuel will be resumed.

"Le Yacht" discusses the class of vessels, of which the *Charlemagne* is the first to complete the official trials, and con-

siders them very fine vessels, with their ability to make 18 knots at full power, and 17 knots with natural draft. The only fault it finds is that the 5.5-inch guns are not sufficiently protected from the effect of explosive shells penetrating the battery below them and tending to cause the failure of the casemates in which they are placed. It says: "We consider that the casemates are not sufficiently supported from below. Without doubt the plates which join them to the protective deck are thick and could stand the attack of numerous projectiles of moderate caliber without failing under the weight which they support, but the explosion of powerful projectiles above the cofferdam belt would probably cause serious injury to the floor of the casemates and might put the guns out of service. From our point of view, the continuity of the protection by the belt between the armored deck and the gun constitutes an enormous advantage.

"That this matter has been considered in high places is proved by the approaching commencement of the battle ship *Suffren*, the disposition of whose light artillery recalls at once the redoubt of the *Brennus* and the turrets of the *Charles Martel;* moreover, we are inclined to believe that the *Suffren* will be followed by another battle ship still more powerful, in which we shall see again the system of heavy guns in a quadrilateral that we made the mistake of abandoning for that of heavy guns in pairs on the midship line. If any guns are to be worked in pairs, they should be rather those of moderate caliber and less importance. Four heavy guns in quadrilateral and twelve of 6.5-inch in six small turrets will, without doubt, be the armament of the new battle ship."

Gaulois.—The Ateliers et Chantiers de la Loire, the builders of the engines of this battle ship, had a preliminary trial about the middle of May, with the following results: Speed, 14.31 knots; I.H.P., 5,170; revolutions of engine, center, 90; starboard, 99; port, 98; coal per I.H.P., per hour, 1.35 pounds. At times, the revolutions were run up to 110 to 112 with an I.H.P. of 8,026. The Belleville boilers with economizers gave excellent results. By comparison with the official trial of the sister ship *Charlemagne* at the same power, it appears that the same speed was obtained, but the *Gaulois* is slightly more economical.

On the 20th of May there was a trial at natural draft, full power. The horse power was 9,123 for 113 revolutions; the average speed was 16.15, and the coal consumption per I.H.P. per hour, 0.670.

On the 26th of May the vessel was tried at nearly full power under forced draft, and gave 13,400 I.H.P. and a mean speed of 17.7 knots.

Both of these trials were made by the contractors for their own information, and with the bottom somewhat foul. The contract speed is 18 knots.

"Le Yacht" remarks in this connection that the vessels of this class are almost comparable with armored cruisers on account of their great radius of action: With the bunkers full of coal they should be able to steam for forty days at eight knots, as shown by the performance of the *Charlemagne*, which made 8.3 knots on 1,590 I.H.P. with a coal consumption of 1.4 pounds per I.H.P. per hour. It has even been suggested that with an additional supply of liquid fuel they might be able to steam for fifty days at a speed of 8 knots.

Masséna.—The full-power trial was successfully carried out on May 10th, in the Bay of Douarnenez. The conditions for the trial were exacting, and are as follows: The trial to be of six hours duration, with all three engines in use, and full boiler power (twenty-four furnaces), but with the blowers discharging into open fire rooms so as simply to assist the draft. Under these conditions the speed was to be 17 knots over a measured course in deep water, with a penalty of 50,000 francs for each tenth of a knot deficiency of speed for the first three. If the speed fell below this, the penalty was to be 100,000 francs for each succeeding tenth of a knot. If the speed fell below 16 knots, the vessel might be rejected, at the option of the Ministry of Marine. The coal burned per square foot of grate was to be between 20.5 and 23.5 pounds per hour, with a penalty of 2,000 francs for each 0.2 pounds above the latter figure. The coal per I.H.P. per hour was to be between 1.94 and 2.18 pounds, with a premium or penalty of 200 francs per gramme for falling below the former or exceeding the latter.

The data of the trial are as follows: average speed, 17.09 knots; I.H.P., 13,460; mean revolutions, 125; coal per hour per I.H.P., 1.94 pounds.

It appears that, as a result of experience on former trials, the rudder had been enlarged with good effect, the steering on this trial being excellent.

The *Massêna* has a displacement of 11,920 tons; length, 383 feet; beam, 65.6 feet; maximum draught, 26.7 feet.

The twenty-four-hour natural-draft trial took place in the latter part of May under very favorable conditions of weather. Twenty-four furnaces were lighted, and the blowers discharged into open fire rooms. The speed was 15.49 knots, with 112 revolutions as the average of the three screws, and an aggregate horse power of 9,650. The coal consumption per I.H.P. per hour was only 1.65 pounds, although the contract permitted it to vary between 1.76 pounds and 1.98 pounds.

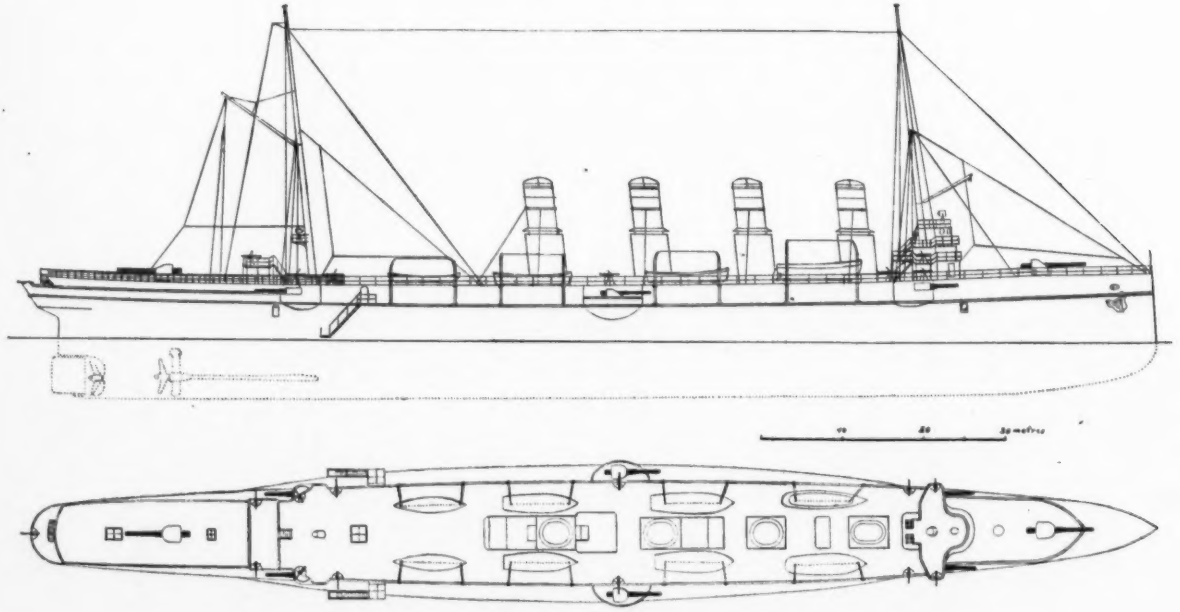
It is interesting to note in this connection that on her preliminary trials the *Massêna* made only 15.1 knots for 9,400 horse power, but this was against a heavy swell. From this it would appear that the speed was reduced nearly four-tenths of a knot on account of the bad weather, and it is evident that trials must take place in good weather in order that the results from different ships may be comparable among themselves.

Bouvet.—This vessel is a battle ship of the same class as the *Carnot*, *Charles-Martel*, *Jaurêguiberry* and *Massêna*, whose displacements range from 11,800 to 12,200 tons, the *Bouvet* being the largest. Length, 400 feet; beam, 69 feet; draught, aft, 27.5 feet. The four-hour full-power trial occurred on May 14th, when a mean speed of 18.18 knots was obtained under rather unfavorable conditions of weather. It is estimated that in a smooth sea the speed would have been one or two-tenths of a knot greater. According to "Le Yacht," this is the highest speed of any of the French battleships, the best previous record being that of the *Charles-Martel*, 18.13 knots. Both these vessels were designed by M. Huin, *directeur des constructions navales*, but the *Bouvet* has eight 10-cm. R.F.G. more than the latter.

Châteaurenault.—The large fast cruiser *Châteaurenault* was

launched on the 12th of May at La Seyne. Some time since the Ministry of Marine invited competitive designs from private builders for two commerce destroyers. Two plans, offering different advantages in their details, were presented, one by M. De Bussy for the Chantiers de la Loire, and the other by M. Lagane for the Forges et Chantiers de la Méditerranée. Each of these establishments was then given an order for a cruiser to be constructed according to its own plans. These plans, while conforming as a whole to the general features dictated by the Ministry of Marine, necessarily differ in the details according to the personal ideas of the designers. The following is the description of the *Châteaurenault:*

First of all, an effort has been made to avoid the appearance of a man-of-war, so clearly discernible in the American destroyers *Columbia* and *Minneapolis*, on account of the retreating bow and stern. The silhouette—and the object will be readily understood—is frankly that of a merchant steamer. The straight stem, the long shear, the overhanging stern and the pole masts all combine to give from a distance the very pacific appearance of some large trans-atlantic steamer. With respect to nautical qualities, the adoption of a straight stem, slightly inclined aft, is advantageous for a vessel intended to maintain a high speed, and, if necessary, in a heavy sea. Experience has demonstrated, in fact, that at a moderately high speed the retreating stem has a tendency to let the waves easily reach the forecastle; on the other hand, the advantage of the ram bow is to permit a more extended negative fire for the bow chaser. Without remarking specially on the practical importance of this quality of negative fire for bow chasers of heavy caliber, we may remark that this has been preserved to a certain extent upon the *Châteaurenault* by the lowering of the forward part of the forecastle deck; in fact, this deck is practically eliminated, so to speak, forward of the position of the 6.5-inch bow chaser. This lowering of the deck permits the gun to be placed sufficiently far aft to give it a solid support, and does not weaken the framing by the recoil, while preserving a sufficient negative fire (about five degrees).



PROTECTED CRUISER "CHÂTEAURENAULT"

There are two pole masts, with signal yards. These masts at their lower part have platforms for search lights.

The funnels are four in number, as on the *Columbia*. The outer casings stop about sixteen feet lower than the funnel proper, which, of course, increases the stability by the suppression of useless weight at a great distance above the center of gravity. (This has been the practice in a number of recent cases in our own ships.—Editor.)

In cross section, the sides above the water line have a slight tumble home.

There is a top gallant forecastle and a poop, which does not show from the outside, because the rail is carried along at the level of these decks. It has been decided, moreover, during the course of construction, that the space between the forecastle and poop—a length of about 190 feet—shall be covered in by a light shelter deck, which will cover the main deck, providing a great increase of berthing space and at the same time a sort of promenade deck.

The following table gives a comparison of the principal dimensions of this vessel and the American ship *Minneapolis*.

	Châteaurenault.	*Minneapolis.*
Length over all, feet	457	414.8
Length between perpendiculars, feet	443	411.6
Beam, feet	55.75	58.2
Draft, aft, feet	24.25	24
Immersed midship section	1,070	1,212
Displacement, tons { on trial	8,018	7,505
Displacement, tons { with normal coal,	...	8,133
Horse power	23,000	21,000
Maximum speed with forced draft { designed,	23	22
Maximum speed with forced draft { on trial..	...	23.07
Total bunker capacity, tons	2,100	1,518
Artillery	two 6.5-inch.	one 8 inch.
	six 5.5-inch.	two 6-inch.
	ten 47-mm.	eight 4-inch.
	.....	twelve 6-pdrs.
	.....	four 1-pdrs.
	.....	four gatlings.

It will be seen that the artillery of the American destroyer is numerically superior to that of the French vessel; on the other

hand, the latter is better provided in ammunition and in coal, which seems preferable for a vessel whose principal qualities should be speed and radius of action. This latter is in the French ship about 10,000 knots, at 12 knots.

In fact, such as it is, the artillery of our fast cruisers seems sufficient to make them superior to any merchant vessel armed as an auxiliary cruiser, and, again, their speed gives them still more the advantage over any cruisers of the enemy which are superior in armament and protection than could an increase of artillery. This increase would involve, moreover, all sorts of consequences, especially from the standpoint of displacement, on account of the increased ammunition and the increased size of machinery.

The battery of the *Châteaurenault* consists of two 6.5-inch guns on central pivot carriages, one on the forecastle and the other on the poop; six 5.5-inch guns, of which four are broadside guns on the main deck, and two are in sponsons amidships; ten 47-mm. guns distributed above the redoubts and at the ends of the vessel. All these guns are rapid fire and are supplied with ammunition from magazines directly under the gun to be supplied. The ammunition hoists work either by hand or by electricity.

With regard to speed, it is known that the American cruisers, after brilliant trials, have not given in service all that was expected from these trial results. [In view of the remarkable trip of the *Columbia* across the Atlantic in 1895, when she averaged for nearly seven days a speed of 18½ knots, this statement of "Le Yacht" is incomprehensible.—Editor.] For reasons which have been given several times in this Journal, we are better protected in France from these disappointments in the ordinary service speed of fast vessels. We have, therefore, a good reason to expect that the *Châteaurenault* will practically have a speed higher than those of foreign vessels of the same class. There will be nothing astonishing, moreover, if the speed of 23 knots, stipulated in the contract, should be sensibly exceeded on trial. The Chantiers de la Seyne are accustomed to do this, and it is sufficient to know that the lines of the *Châteaurenault* were

designed by M. Lagane to be satisfied of their fineness and appropriateness to the highest possible speed.

The propelling machinery of the *Châteaurenault* consists of three triple-expansion vertical engines, each working a separate screw and developing an aggregate horse power of 23,000 at about 124 revolutions. The boilers, which originally were to be of the Lagrafel-D'Allest type, have been changed, and for the first time in a large ship will consist of fourteen Normand-Sigaudy boilers, with small tubes, divided into four unequal groups, three of four each, and one group of two forward. The machinery occupies the lower part of the vessel for half its length. The weight is practically the same as that of the machinery of the *Minneapolis*—about 1,950 tons.

The differences in the distribution of the weights which make up the displacement of the two vessels, are chiefly marked in the protection and supply of coal. The armored deck of the French vessel, as compared to that of the *Minneapolis*, is in the ratio of six to ten. As regards coal supply, however, that of the *Châteaurenault* is about once and a-half that of the *Minneapolis*. This fact confirms the impression, which a comparison of the other elements of the two vessels suggests, that the *Châteaurenault* is more frankly a commerce destroyer and less a cruiser, in the military sense of the term, than the older American vessel.

The protection is that required by the official specification and the armored deck is 2½ inches on the slopes. The flat rises to a little over 3 feet above the water line at the center, and at the lower edges of the slopes is about 4½ feet below. The artillery is sheltered by fixed redoubts and shields.

Except the boat winches, of which there are four, worked by steam, all the auxiliary machinery for guns, ammunition hoists, etc., is worked by electricity, with provision for working by hand in case of accident.

The electric plant consists of four dynamos of 600 ampères and eighty volts, any three of which are sufficient for the duty, the fourth serving as a standby. There are twelve electric ammunition hoists, two for the 6.5-inch, six for the 5.5-inch, and four for the 47-mm. guns. The electric installation also includes three

Rateau ventilators, three Peruisse engine-room telegraphs, and six search lights worked from a distance.

The lighting is provided by 450 incandescent lamps of from ten to sixty candles.

The crew of the vessel will consist of 17 officers, 10 midshipmen, 50 petty officers, 114 leading men, and about 400 blue jackets.

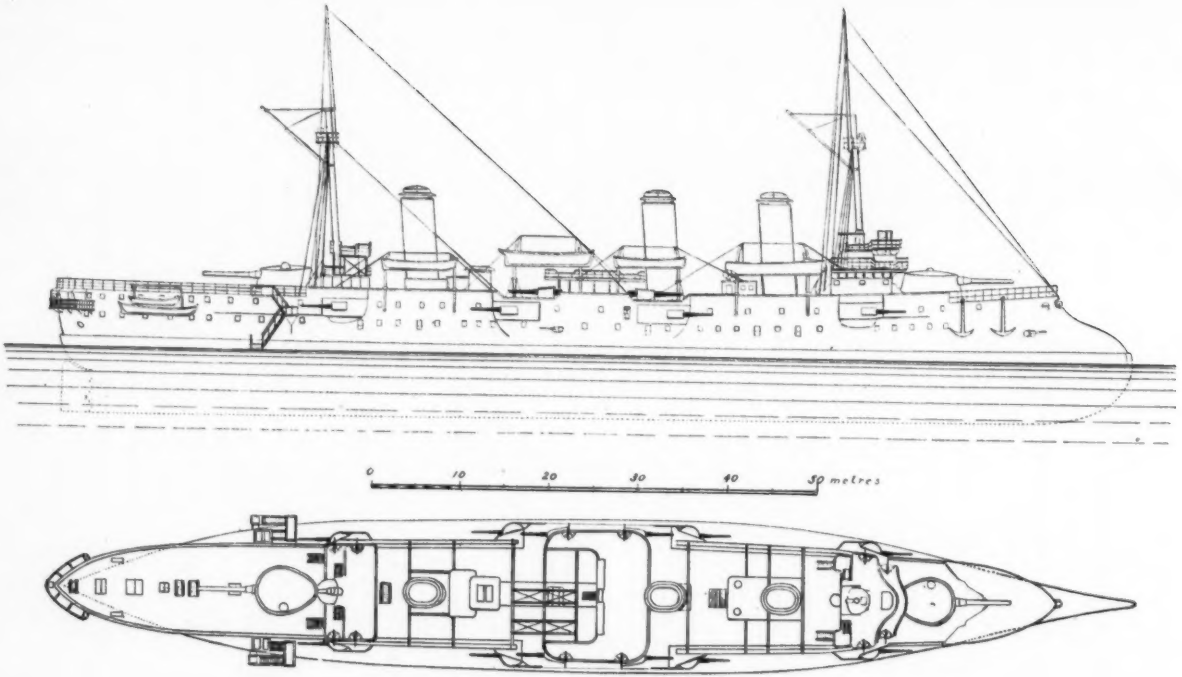
The vessel is to be delivered at Toulon on the 8th of July, 1899. The keel was laid the 8th of May, 1896. When launched the armored deck was in place, and the upper works well advanced.—[Translated from "Le Yacht."]

In the launch of this vessel, these works used, for the first time, a new plan for stopping the vessel after leaving the ways. The only feature retained of former methods is a few breaking stoppers, and these are combined with dead weights of 24 tons of pig iron (12 on each side) which are dragged on the ground, thus forming a powerful brake, capable of absorbing the momentum of the vessel. The launching weight of the hull, as it left the ways, was about 3,500 tons. The weights were dragged a distance of about 50 meters, as had been previously estimated, and the vessel was then brought up with only two of the stoppers broken.

Guichen.—"Le Yacht" states that this vessel, which is a sister to the *Châteaurenault*, will be ready for trial this autumn, and gives a synopsis of the conditions of the trials, which are as follows:

First. Trial at maximum speed and power. This is to last three hours, with thirty-six furnaces, and under forced draft. The power expected is 24,000 horses, at 124 revolutions, and a speed of 23 knots. The combustion is not to exceed 30.5 pounds per square foot of grate. There is a penalty of 5,000 francs for each one-tenth of a knot below the contract speed for the first five tenths, and 10,000 francs for each succeeding one-tenth. For each pound above 30.5, there is a penalty of 49,000 francs. If the speed is below 21 knots, the vessel may be rejected.

Second. Natural-draft full-power trial. This is to last for twenty-four hours, and the horse power is to be 14,500, with 105



PROTECTED CRUISER "D'ENTRECASTEAUX."

revolutions, the speed not being stated. The coal consumption may be between 1.76 and 1.87 pounds per I.H.P. per hour. If the consumption falls below 1.76, there will be a premium of 200 francs for each gramme, and if it exceeds 1.87, there will be a penalty of like amount for each gramme.

Third. There will also be consumption trials lasting six hours, at 1,900 horse power and at 8,500. The speed is not fixed for these trials, but will be carefully observed for purposes of information.

D'Entrecasteaux.—The official trials of this vessel have recently been carried out. The principal dimensions are as follows: Length between perpendiculars, 383.75 feet; beam at water line, 58.55 feet; mean draught, 23.45 feet; displacement, 8,114 tons; maximum I.H.P., 13,500, and speed, 19 knots.

The battery includes two 9.6-inch B.L.R., in closed turrets; twelve 5.5 R.F.G., of which eight are in armored redoubts and four upon the spar deck; twelve 47-mm. and four 37-mm. distributed on the bridges. There are also six torpedo-tubes, of which two are submarine. The masts have been reduced to two light signal masts.

The boilers, since the original design, have been arranged for the use of liquid fuel in addition to coal. To this end there have been fitted in the double bottoms tanks for about 10,000 gallons of liquid fuel. The burners will be fed by Thirion pumps drawing from special reservoirs.

Electricity is used to a very large extent for auxiliary purposes. Besides working the turrets it will be used for all the lighting, for engine-room telegraphs, for working the blowers, ash hoists and ammunition hoists. The electric plant consists of six dynamos divided into two groups. The forward group is placed in the compartment below the 9.6 turret, and comprises two dynamos, while the group placed under the after turret comprises four. The interior lighting will be furnished by 410 lamps of 10-candle power, and the exterior by 56, of from 10 to 50 candles. There are six Mangin search lights provided for working from a distance. There are six ash hoists, which were originally to be worked by steam, but are now to be worked either by electricity or hand

power. There are three electric ammunition hoists for the 37 and 47-mm. guns, ten for the 5.5-inch guns and two for the 9.6-inch guns.

The normal coal supply is 650 tons, which may be raised by filling of available space to 950. These figures correspond to 5,500 miles at 10 knots and 1,250 miles at 19 knots for the normal supply, and to 8,000 miles and 1,700 miles with the full available supply.

The gunnery trials were very satisfactory, and it was found during the trials for rapidity that the 9.6-inch guns could be fired with an interval of about a minute and a-half, with a new aiming of the gun for each fire.

A coal-consumption trial lasting six hours was made with the starboard engine only, supplied from two boilers. The horse power developed was 1,605, and the coal consumption per I.H.P. per hour was eighty grammes less than that stipulated in the contract for a power of 1,500 horses. The speed was an average of about 10 knots, with revolutions varying from 59 to 64 turns.

D'Assas.—Changes have been made in the ventilation of the magazine for 6.5-inch guns. The temperature was excessive, on account of its position between two boiler compartments. A refrigerating machine is fitted and is very efficient, being able, in fact, to lower the temperature sufficiently to cause a deposit of frost on the cooling coils. But besides the expense of running this machine, provision must be made for the possibility of its stoppage. As a consequence, arrangements have been made for admitting cold air from outside and exhausting the hot air.

Dupleix.—The Forges et Chantiers de la Méditerranée will build in their Havre shops the engines of this armored cruiser. There will be three engines, each driving a manganese-bronze screw of the ordinary built-up type.

The boilers of the *Dupleix* will be built by the Belleville Company at their works at St. Denis. There will be twenty-four of these boilers, divided into four groups of six each. Two of the groups will be forward of the engines, and two aft. The fire rooms will run athwartships.

Desaix.—The Ateliers et Chantiers de la Loire have recently

received a contract to build an armored cruiser of this name, intended for service on foreign stations. The length is 426.35 feet; beam, 58.38 feet; draught, 24.34 feet, and the displacement, 7,700 tons. The contract price is 15,470,000 francs. The horse power will be 17,000 for three engines driving three screws, and the speed 21 knots. The battery consists of ten 6.5-inch rapid-fire guns, of which two will be in turrets on the midship line, and the other eight in armored casemates on the broadside. The armor belt will be 4 inches thick at the water line. The design of the *Desaix* is by M. Bertin, Director of Naval Construction. There will be twenty-four Belleville boilers of the new type, with economizers, carrying 285 pounds steam pressure.

La Zélée.—A gunboat of this name has been laid down at Rochefort, and is a modification of the *Decidée*, or *Surprise* type. The hull will be of hardened steel plates, she will have three masts, and be rigged as a barkentine. There will be six officers.

The following are the dimensions of this little vessel, designed for foreign stations, and consequently sheathed with copper: Length, 184 feet; beam at water line, 26 feet; maximum beam, 26.4 feet; mean draught, 10.15 feet; displacement, 646 tons.

The two Niclausse boilers will furnish steam to a horizontal triple-expansion engine of 900 horse power. The maximum speed is expected to be 13 knots. The normal coal supply is 75 tons, giving a radius of action at 10 knots of 2,700 miles, and about 1,000 miles at 13 knots.

The armament will be entirely of rapid-fire guns, and will consist of two 3.9-inch, four 2.6-inch and four 37-mm.

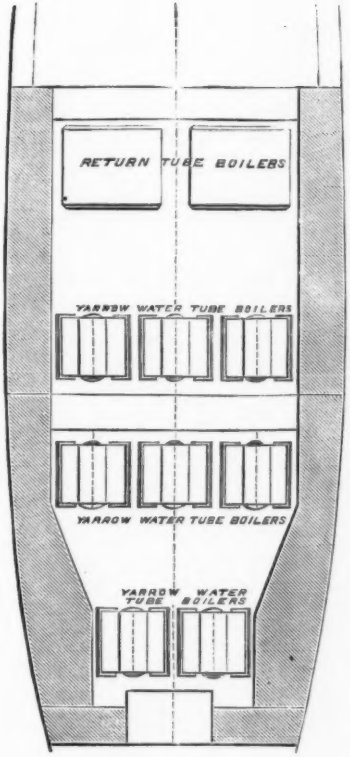
HOLLAND.

Friesland, Zeeland and **Holland.**—In the February JOURNAL we gave on account of the trials of the *Friesland*. It will be remembered that Mr. Andrae, the Engineer-in-chief to the Dutch Navy, determined to try the result of a combination of small tube or express water-tube boilers and return-tube boilers in these vessels, and selected the Yarrow boiler as most suitable for the purpose. As a consequence Messrs. Yarrow and Co. were commissioned to construct, at their works at Poplar, one Yarrow

boiler for each ship, making three in all, and these were intended to act as examples for the remaining water-tube boilers required that were to be made in Holland. We have been furnished with the particulars of the trials of these vessels, but before repeating them it will be convenient if we give some details of the vessels themselves.

The *Friesland* has been built and engined by the Maatschappij voor Scheeps en Werktuigbouw Fijenoord at Rotterdam, an establishment of which Mr. Croll is the director; and the *Zeeland* by the Koninklijke Maatschappij de Schelde at Flushing, of which Mr. van Raalte is director; whilst the *Holland* was built in the Royal Dockyard at Amsterdam, and engined by the Nederlandsche Fabriek van Werktuigen en Spoorweg Materieel at Amsterdam, of which Mr. Strumphler is the director. These vessels are 306 feet long by 48 feet 6 inches beam and 17 feet 9 inches draught. The displacement is calculated at 3,900 tons with 400 tons of coal on board, the total coal supply being 850 tons. The vessels are twin-screw, and have triple-expansion engines with cylinders 33 inches, 49 inches and 74 inches in diameter by 39 inches stroke. The propellers are 14 feet diameter by 16 feet pitch, and have 60 square feet of surface. It may be noted that the propellers of the *Holland* turn outwards, and those of the other two ships inwards.

The boilers, which are the most interesting part of the machinery, consist, in each ship, of two of the return-tube type, having a grate surface of 126 feet and a heating surface of 4,005 feet. The eight water-tube boilers have 322 square feet of grate and a heating surface of 16,136 feet. As stated, Messrs. Yarrow made one boiler for each vessel, the remainder being constructed by the Dutch firms. The total maximum horse power for which the boilers of each ship were designed to supply steam was 9,250 indicated. Of this, 2,250 horse power was to be obtained from the two return-tube boilers, and the remaining 7,000 horse power from the eight Yarrow boilers. The weight of the return-tube boilers with water was 120 tons, and that of the eight water-tube boilers with water 88 tons. The total weight of propelling engines and boilers and water, together with pumps, fans, funnels, floor-


RETURN TUBE BOILERS
YARROW WATER TUBE BOILERS
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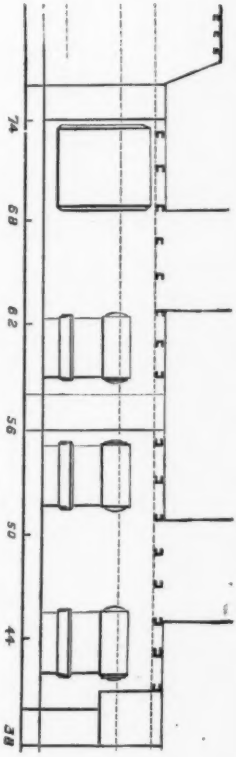
YARROW WATER TUBE BOILERS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38

RESULTS OF TRIALS OF DUTCH CRUISERS.

Date.	Speed.	Revolutions.	Indicated horse power.	Air pressure in inches of water.	Number of boilers.	Coal consumption per indicated horse power.	Time.	Remarks.
	knots.					*lbs. per hour.*	*hours.*	
				Friesland.				
Oct. 18, 1897.....	10.423	71.6	1,077	...	3 W.T.	...	4	No auxiliary engines included in the coal consumption.
Oct. 19, 1897.....	12.528	87.25	2,006	...	4 W.T.	1.84	6	
Oct. 20, 1897.....	17.275	124.2	5,982	0.4 in.	All 10	1.62	4	
Nov. 3, 1897.....	19.87	147.27	10,416	0.8 in. to 1.16 in.	All 10	1.67	4	
Nov. 3, 1897.....	Maximum.	148.3	10,850		All 10	...	...	
				Zeeland.				
Dec. 28, 1897....	10.24	64.2	1,162	...	3 W.T.	...	4	Propellers at 17½ feet.
Dec. 29, 1897....	12.4	78.6	2,062	...	4 W.T.	...	6	
April 5, 1898....	19.47	138.58	9,818	1.2 in. to 2 in.	All 10	2.06	4	All auxiliary engines included in the coal consumption.
April 5, 1898....	Maximum.	141.5	10,589	1.2 in. to 2 in.	All 10	...	...	
April 6, 1898....	16.466	114.22	5,203	0.4 in.	All 10	2.1	4	Propellers at 16 feet.
				No feed heater was fitted in this case.				
				Holland.				
Feb. 6, 1898.....	9.973	70.04	1,216	...	3 W.T.	...	4	
Feb. 9, 1898.....	11.63	80.51	1,778	...	4 W.T.	...	6	
Feb. 24, 1898....	16.92	123.0	6,236	0.4 in.	All 10	...	4	All auxiliary engines included in the coal consumption.
May 10, 1898....	19.618	145.86	10,541	0.8 in. to 2 in.	All 10	2.28	4	
...	Maximum.	149.9	11,712	...	All 10	...	...	Ship docked last, February 4.

GENERAL REMARKS.—The indicated horse power is the indicated horse power of the chief engines only. The stokers on board the *Zeeland* and *Holland* had not been so well trained as on board the *Friesland*.

plates, ladders, and all other things which can be included under the category of propelling machinery, was, for the *Holland* 635 tons, for the *Friesland* 611 tons, and for the *Zeeland* 570 tons. The *Holland* and *Friesland* have Weir's feed pumps and feed heaters. The *Zeeland* is fitted with Yarrow's automatic feed control arrangement, and has a Worthington pump to each boiler, but has no feed heater. There are steam steering engines, dynamos for electric light and for search lights, air compressors for torpedoes, steam capstans, refrigeration engines, Sturtevant blowers for ventilating purposes and to supply hot or cold air, evaporators, feed-water filters, and other auxiliary machinery and fittings.

The results of the trials are given in the annexed Table. The steam pressure in both return-tube and water-tube boilers was 200 pounds to the square inch.

The object of the Dutch naval authorities in adopting the combined arrangement of boilers was to gradually accustom the stokers to the new type. In three similar cruisers being built in Holland, and which are to be launched shortly, Yarrow boilers only are being fitted, there being twelve in each vessel.

It may be interesting to compare the results obtained on the trials of these vessels with those of the *Diadem*, which affords an example of the most recent type of British cruiser. Putting the weight of the machinery in the three Dutch vessels at 605 tons and the mean maximum horse power at 10,260, we have 16.9 horse power developed per ton weight of machinery. If the weight of the *Diadem's* machinery was 1,437 tons, and the horse power developed 17,262 (see Sir John Durston's paper read at the last meeting of the Institution of Naval Architects), it will be seen that 12.01 horse power was developed per ton weight of machinery. It must be borne in mind, however, that the *Diadem's* full-power trial extended over eight hours, while that of the Dutch cruisers was but of four hours' duration. If every allowance be made, however, there can be no doubt that the adoption of the express type of boiler gives an enormous advantage in regard to lightness of machinery, and therefore of speed; and it may be said generally that the results bear out the wisdom of the choice of the Dutch naval authorities.

ITALY.

Proposed New Battle Ships.—Three new battle ships not yet named, and which were designed by the late Minister of Marine, Signor Brin, who besides being a diplomatist was an accomplished naval constructor, are about to be laid down at Castellamare, Spezzia and Venice. The following is a brief general description: Length over all, 441 feet; length between perpendiculars, 414 feet; beam, 78 feet; mean draught, 27.1 feet; displacement, 12,400 tons.

This new type, a result of the new ideas accepted nowadays by the principal maritime powers, is intermediate between the battle ships and armored cruisers previously designed. The form recalls that of the torpedo boat. The protection consists of a complete belt fore and aft of nickel-steel from 6 feet above the water line to $3\frac{1}{2}$ below, and of a thickness of 6 inches at the center and 2 inches at the extremities.

Two armored athwartship bulkheads, 10 inches thick, form in the center, in conjunction with the belt, a citadel. The armored deck extends throughout the entire length of thicknesses varying from 3.2 inches to 1.6 inches.

The machinery consists of twin screws driven by four-cylinder triple-expansion engines, designed to develop 14,000 I.H.P. with natural draft, and 18,000 I.H.P. at forced draft, giving speeds respectively of 18 knots and 21 knots.

The normal coal supply will be 1,000 tons, corresponding to a radius of action at 10 knots of 5,000 knots, but this amount of coal may be doubled in case of necessity.

The armament consists of two 12-inch B.L.R. in a turret aft of the citadel, with 6-inch armor, and ten 8-inch rapid-fire guns in five turrets six inches thick; one of these turrets is forward and the other four are on the broadside at the corners of the citadel; sixteen 76-mm. and eight 47-mm. R.F.G. and four torpedo tubes.

Armored Cruisers.—Two new armored cruisers to replace the *Garibaldi* and *Varese*, sold to other countries, have been ordered to be built at Leghorn and Genoa, two years being allowed for the construction. They will have a length of 343 feet, and a more

powerful armament than the former vessels. They will be fitted with water-tube boilers, which will enable a greater speed to be attained.

Carlo-Aberto.—The recent trials of this vessel at Spezzia gave a speed of 19 knots and 13,266 horse power. She is an armored cruiser of 6,500 tons, a sister to the *Vettor Pisani.*

JAPAN.

Tokiwa.—The first-class armored cruiser *Tokiwa*, built for the Japanese Navy, was launched on the 6th of July from the Armstrong Works at Elswick. The particulars of special interest in relation to her are the following principal dimensions: Length, 408 feet; breadth, 67 feet; draught, mean, 24 feet 4 inches; displacement in tons, 9,700. Armament: Four 8-inch breech-loading guns, fourteen 6-inch quick-firing guns, twelve 12-pounder quick-firing guns, seven 2½-pounder quick-firing guns and five torpedo tubes. These guns can be so trained that fifteen guns can fire directly ahead, viz: Two 8-inch guns, four 6-inch guns, six 12 pounder guns, two 2½-pounder guns and one torpedo. Fourteen guns can fire directly astern, viz: Two 8-inch guns, four 6-inch guns, six 12-pounder guns, two 2½-pounder guns. Twenty-five guns can fire on either broadside, viz: Four 8-inch guns, seven 6-inch guns, six 12-pounder guns, six 2½-pounder guns, two torpedoes. Armor: Complete belt, 7 inches to 3½ inches; citadel, 5 inches; casemates, 6 inches; barbettes, 6 inches; conning tower, 14 inches. Speed: 21½ knots with 18,000 indicated horse power; forced draft, 20 knots with 13,000 indicated horse power open stokeholds. Coal supply: normal, 600 tons; full, 1,200 tons.

Kasagi.—Another feather is added to the cap of the William Cramp & Sons Ship and Engine Building Co. as a result of the very successful trial of the Japanese cruiser *Kasagi*, over a 40-mile course off the Massachusetts coast in the latter part of June. The *Kasagi* is the cruiser which the United States Government made an unsuccessful attempt to purchase at the outbreak of the war, and the Cramp Company finds a further cause for gratification in their achievement of completing the vessel full six months

ahead of the contract time. A strong cross tide and other unfavorable circumstances made the conditions for the trial not of the most satisfactory nature, and yet the *Kasagi* developed a speed of 21.68 knots under natural draft and 22.76 knots under forced draft, the contract calling for 20.50 knots under natural draft. Engineer-in-chief Edwin S. Cramp was naturally delighted with the constantly increasing excellence of the work done by the engines. The revolutions of the screws rose from 158 at the beginning of the run to 164 at the close. This was accomplished with an even pressure of steam and an air pressure of about 1½ inches in the fire rooms. After the regular trial the perfect condition of the machinery was attested by a series of progressive trials to get the speeds at 80, 125, 150 and 160 revolutions. On the run from Philadelphia to the regular course a speed trial under natural draft was made. On this occasion the speed of the cruiser under practically natural draft (fire rooms closed with blowers giving ½-inch air pressure) was 21.65 knots. The completion of the vessel ahead of contract time is the first case of the kind on record. The Japanese officials aboard expressed themselves as perfectly satisfied with the cruiser, which will be sent to England to receive her armament.

A very complete coal test was made during the trial trip, although results are not yet obtainable, and at the conclusion of this a test was made to determine the maneuvering ability of the cruiser. With full speed, thirteen revolutions per minute of the engines, complete circle to starboard, the time was four minutes fifteen seconds. With same conditions, but going to port, four minutes sixteen seconds. The circle in each case was less than 300 yards. Full speed ahead, reversing and coming to complete stop, two minutes twenty-five seconds, or in the vessel's own length. A remarkably close calculation is related of the mileage made by the ship on the home trip. The distance from Portsmouth to the Five Fathom light is exactly 446 miles. The trip was made some of the way in the fog, and the lights could not be seen. The ship had lost her log, which indicated the speed, and the distance was calculated by the revolutions of her engines. When the Five Fathom light was reached on June 20th,

the calculated distance was only a mile and a-half out of the way. —" Marine Record."

PORTUGAL.

Sao Gabriel.—The Forges et Chantiers De La Méditerranée at Havre, launched, on the 7th of May, the cruiser *Sao Gabriel*, built for the Portuguese Government. The length is 246 feet, the beam 32.8 feet and the draught 14 feet. There will be twin-screw engines of 2,600 horse power.

Don Carlos I.—The Armstrong works, on the 5th of May, launched at Elswick the first-class cruiser *Don Carlos I.*

The hull is of steel sheathed and coppered, with double bottoms and water-tight compartments. Length, 360 feet; beam, 47.25 feet; mean draught, 17.50 feet; displacement, 4,100 tons. The protection is an armored deck, 1.6 inches on the flat and 4.4 inches on the slopes. It extends throughout the entire length of the vessel. The conning tower is 4 inches thick. There will be a cofferdam around the engines and boilers. There will be two vertical triple-expansion engines of four cylinders each in separate water-tight compartments. There are twelve Yarrow boilers, carrying a pressure of 290 pounds, and enabling the machinery to develop 12,500 horse power under forced draft, and giving a speed of 22 knots. Under natural draft the horse power will be 7,500, and the speed 20 knots. The normal coal supply is 700 tons, which may be increased to 1,000, thereby giving a radius of action of 10,000 miles at 12 knots and 2,000 horse power. The armament consists entirely of rapid-fire guns, and includes four 6-inch, eight 4.7-inch, twelve 47-mm. and four machine guns. There are five torpedo tubes, of which three are submerged and two above water.

RUSSIA.

Peresviet.—The armored cruiser *Peresviet* was launched at the Baltic Works, at St. Petersburg, on the 19th of May. The displacement is 12,675 tons; length, 436.25 feet; beam, 71.5 feet, and draught, 25.90 feet.

The protection consists of a belt of Harveyized nickel-steel, ordered from the Carnegie Steel Company, which is 9.2 inches

thick amidships, and six inches at the extremities, and an armored deck. Three triple-expansion engines will be supplied with steam by thirty Belleville boilers at a pressure of 160 pounds, and drive three screws with an aggregate horse power of 14,500 at 115 revolutions, giving a speed of 18 knots. The battery includes four 10-inch, 45-caliber B.L.R. in two turrets, one forward and one aft; eight 6-inch guns upon the upper deck, in armored casemates; five 4.7-inch and seventeen R.F.G. of 57 and 47 mm. There are six torpedo tubes. A similar vessel, still on the stocks at the New Admiralty, will soon be launched and will be replaced on the stocks by a similar cruiser.

Gromoboi.—On the same day that the *Peresviet* was launched, the *Gromoboi* had her keel laid in the place of the former. She is of the same type as the *Peresviet*, but larger and intended to make 20 knots.

New Battle Ships.—The new battle ships about to be constructed will be of the *Peresviet* type, intermediate between battle ships and armored cruisers. The displacement will be 12,500 tons, the horse power 14,500, and the speed 20 knots. They will have four 10.8-inch B.L.R., eight 6-inch and five 4.7-inch R.F.G.

Pallada.—The protected cruiser of this name is nearly ready for launching at the Neva Works. She is of 6,500 tons displacement, 11,000 horse power and 20 knots speed. Her place on the stocks will be taken by a third cruiser similar to the *Gromoboi*.

Moskva.—The Clydebank Engineering and Shipbuilding Company, Limited, launched, on the 23d of May, the *Moskva*, a high-speed mail and passenger steamer, which has been designed and constructed for the Russian Volunteer Fleet. In peace times, the vessel is intended to maintain a regular service between the port of Odessa, in the Black Sea, and Vladivostock, in Siberia. For this purpose her holds and hatchways are arranged so that she may be able to carry a large quantity of machinery and other engineering material on the outward voyage, as well as a large number of emigrants, also first-class and third-class passengers. On the homeward journey the staple cargo of the vessels of this company is tea. The dimensions of

the vessel are: Length over all, 508 feet; length between perpendiculars, 470 feet; breadth, 58 feet 3 inches; depth, 37 feet, and gross tonnage, 7,400. She will carry 74 first-class passengers, 50 third-class passengers, and 1,536 emigrants or troops. There is a large first-class saloon on the upper deck forward of the machinery, fitted in polished mahogany, and on the bridge deck above is a handsome music saloon. In time of war, the *Moskva* can be converted into a powerful auxiliary cruiser, for which duty her estimated speed of 20 knots will render her doubly efficient.

The decks are strengthened and supported in such a way as to admit of eight guns of 4¾-inch caliber and an equal number of 3-inch caliber being mounted in time of war. The magazines for the ammunition are portable, and will be kept on shore at Odessa, ready to be put on board at a moment's notice, and arrangements are even made for ammunition hoists to enable the ammunition to be served quickly to the guns.

The ship is propelled by two sets of three-cylinder, vertical, triple-expansion engines. The cylinders are 36½ inches, 61 inches and 103 inches in diameter by 54 inches stroke. The high and intermediate-pressure cylinders are fitted with piston valves having approved adjustable packing rings, while the low-pressure cylinders are fitted with treble-ported flat slide valves, with a special type of relief frame at the back to relieve them of steam pressure. All the valves are worked by a single-eccentric, radial valve-gear, operated by a single eccentric through a quadrant rocking on trunnions. Steam is supplied by thirty water-tube boilers of the Belleville type; the safety valves on the boilers are loaded to a pressure of 250 pounds. The boilers have a total heating surface of 46,000 square feet, and a grate surface of 1,394 square feet.

Electric Launch.—Recently a trial was made of an electric launch built to the order of the Imperial Russian Ministry of Marine by the Vril Launches Company, of St. Helen's and Cowes, Isle of Wight, the London offices of the Company being 19 Coleman street, E. C. The boat is an open launch, 32 feet long, 8 feet wide, and 3 feet 3 inches deep. She has a double

skin of mahogany, and all the fittings are of gun metal, nickel plated; indeed, no expense seems to have been spared in the construction and finish of the little vessel, which is a remarkable example of the boat builder's art. Perhaps the excessively high polish of the woodwork savors more of the cabinet maker than the boat builder, though that is a blemish that will soon cure itself, and the unnecessary nickel plating of gun-metal knees and fittings is by no means pleasing to the nautical eye, and, indeed, gives the boat a tin-can appearance, far inferior to the warm hue of good, solid gun metal. The launch is intended for the Russian lakes, so no doubt the appearance will not matter much, and it is but fair to say that the superfine finish does not cover up flimsy work, the boat appearing well and strongly built throughout.

The machinery consists of a 7,000-watt motor supplied with current by forty E.P.S. Faure-King accumulators, the latter being fitted in specially designed water-tight and acid-tight ebonite boxes, which are placed in the usual position under the seats. The vertical type of motor has been adopted, this being placed inside a very shiny French polished box in the middle of the boat.

The field magnets are of cast steel and series-wound in two equal circuits. The armature is wound in two distinct circuits, and has a commutator at each end. The brush gear is of delta metal, carbon brushes being used.

The method of working the machinery is unusual. In order to avoid running the batteries in parallel or the motor at half voltage, the latter is so arranged that it forms what is, in effect, a pair of motors. When the boat is started either ahead or astern the first movement of the controller puts the full battery on to the motor, which is connected up so as to form practically two motors in series, one field winding and armature winding in series being in series with the other field and armature in series. When the controller is put to full speed the motor is connected up as two in parallel; that is to say, one field and armature is in series in parallel with the other field and armature in series. The object of this arrangement is to do away with the method of

regulating by either varying the number of cells or by putting cells in parallel and series in groups, it being undesirable to run batteries in parallel, whilst motors are not efficient at low voltage.

A run was made from the Portsea Pontoon up Portsmouth Harbor towards Portchester. The designed speed at ten electrical horse power is eight miles an hour, the batteries supplying current for four hours at that working. At half power the time the boat would run without recharging would naturally be eight hours, and the speed would not be so very far short of the eight miles, for the latter is a long way over the natural speed of a 32-foot boat, and the last two knots require a deal of extra power. The total weight of the machinery is 48 cwt.

The passenger capacity of boats of this class was well illustrated, there being over twenty people on board without at all crowding. The electric horse power developed was about $11\frac{1}{2}$, there being from 122 to 124 ampères at 70 volts. The machinery ran easily and well, and the trip was altogether a success.—"Engineering."

Battleship of 12,700 tons displacement and 18 knots speed, building by Cramp & Sons.—(No. 300 on list at Cramps.)—Length between perpendiculars, 376 feet; breadth, 72 feet $2\frac{1}{2}$ inches; draught, not to exceed 26 feet; displacement, 12,700 tons; normal coal, 8 per cent.; displacement, 1,016 tons; coal capacity, 2,000 tons; speed at natural draft for twelve hours, 18 knots.

Armament.—Four 12-inch guns, 40 calibers, in revolving turrets of 10-inch armor; twelve 6-inch guns, 45 calibers; twenty 3-inch guns, 50 calibers; twenty 47-mm. Hotchkiss; six 37-mm. Hotchkiss.

Torpedo Armament.—Four under-water transverse torpedo tubes; two above-water transverse torpedo tubes.

Armor.—Krupp's patent. Thickness of belt for two-thirds length, 9 inches; thickness of turrets, 10 inches; thickness of barbettes, 9 inches; thickness of casemate, 5 inches; upper bow, 2 inches.

Boilers.—Water-tube, Niclausse type.

6,500-ton protected cruiser, 23 knots speed, building by

Cramp & Sons.—(No. 301 on list at Cramps.)—Length between perpendiculars, 400 feet; beam, 52 feet; draught, about 19 feet 6 inches; displacement, 6,500 tons; coal, normal, 770 tons; coal capacity, 1,250 tons; speed for twelve hours under natural draft, 23 knots.

Armament.—Twelve 6-inch guns, 45 calibers; twelve 3-inch guns, 50 calibers; six 47-mm. guns, 50 calibers.

Torpedo Armament.—Six torpedo tubes above water.

Boilers.—Water-tube, Niclausse type.

The contract time is 30 months for the battleship and 20 months for the cruiser.

It will be noted that the schemes for these ships exceed the requirements of any other battle ship or cruiser heretofore constructed.

In the first place, 18 knots for battle ship and 23 knots for cruiser has to be maintained under natural draft for a period of twelve hours duration.

This has to be secured under a load of coal, ordnance, complement, stores, spare water, &c., 50 per cent. greater than the requirements of any other country outside of Russia.

Each vessel is to be provided with evaporators of such capacity as to supply the loss of water in the boilers during the whole radius of action for which the maximum supply of coal will last.

MERCHANT STEAMERS.

Alexander McDougall.—On June 20 the largest vessel ever constructed at the head of the lakes will be launched from the shipyard of the American Steel Barge Company, West Superior, Wis.

The new steamer, to be named *Alexander McDougall*, in honor of the general manager of the company, is 430 feet over all. The *Thomson*, *Bartlett* and *Colby*, which were constructed several years ago, were all under 300 feet, and at that time were considered large vessels. Later the *Mather*, *Wilson*, *Colgate Hoyt* and *Trevor*, which were 320 feet in length, were turned out; then came the *Frank Rockefeller*, 380 feet long, the *John Ericsson*, 404 feet in length, and now the *McDougall*, with a length of 430 feet.

The principal hull dimensions are 430 feet over all, 414 feet keel, 50 feet molded depth, and 27 feet deep. She has a double bottom 5 feet deep, extending fore and aft, with forward and after-peak tanks, having a total water-ballast capacity of 2,000 net tons. It is expected that she will carry 7,200 tons, or an equivalent of 240,000 bushels of wheat, on the ordinary lake draught. Her propelling power will consist of a set of quadruple-expansion engines of the Cleveland Ship Building Company's make, with cylinders, 19, 28, 43, 66 inches diameter, having a stroke of 40 inches. There are two boilers of the Babcock-Wilcox water-tube type, which will supply steam to the engines at 250 pounds pressure. This vessel is constructed of steel throughout, and has thirteen cargo hatches, each 24 by 8 feet in the clear, spaced 24 feet centers, in addition to large hatch for coaling purposes, the coal-bunker capacity being 350 tons. Two steel pole masts will be fitted, about 90 feet long, with a "crow's nest," for the lookout on fore mast.

There is a departure in this vessel from others of the whale-back type, inasmuch as she is built with a "straight stem" and

"top gallant forecastle" in lieu of the well-known "spoon bow," now so familiar on the lakes. Accommodations are provided under the top gallant forecastle for the berthing of crew, wheelsman, watchman, etc., as well as lamp room, store room, lavatories, etc. The "texas," having accommodation for captain and mates, with bridges and pilot house above, is well forward, just abaft the forward hatch, and is connected to the forecastle head by a portable bridge. There is a large single turret aft inclosing the entrance to stokehold and after quarters, firemen's quarters, engineer's cabin, etc. On top of after turret is a commodious steel deck house containing captain's spare room and quarters for chief engineer, steward, dining room, kitchen and pantry, crew's mess, staterooms, bathrooms, etc. The cabins and furniture are of polished hardwood, and will be equal in style to the most elegant passenger-ship fittings. There is a complete installation of electric lights, including arc lights on deck and in holds for facilitating the working of cargo at night. Steam steering gear, duplicate ballast pumps, ash pumps, steam winches and capstans are fitted, all of the latest and most improved style. This latest addition to the American Steel Barge Company's fleet is the largest of her type afloat, and will be numbered among the one or two "monsters" of the Great Lakes.—"Marine Record."

Hendrick S. Holden.—The large steel steamer *Hendrick S. Holden* was successfully launched from the yards of the Globe Iron Works Co., Cleveland, on Saturday, June 25, and was christened by Miss Mary Stewart.

The general dimensions and particulars of the *Holden* are as follows: 430 feet over all, 410 feet keel, 50 feet beam and 28 feet deep. She will be in all respects equal to the best cargo-carrying steamer on the lakes. Her two pole spars are of steel. She has twelve cargo hatches, spaced 24 feet centers, and all forward of the coal bunkers. The hull in all its parts is of the best mild steel, and the construction is in accordance with the highest class known in the art of steel shipbuilding, and so as to secure a high rating in universally known classification registers of American and foreign shipping.

The engine is of the four-cylinder, quadruple-expansion type, having cylinders 20¼, 30¼, 44, 63½ inches diameter by 42 inches stroke. The valves on the high-pressure and intermediate-pressure cylinders are of the piston type, while the low-pressure cylinder has a double-ported slide valve. The first and second intermediate valves have counter-balance cylinders, while the low-pressure valve is operated by a Joy patent assistant cylinder, which is so designed as to take the stress off the valve gear as completely as possible. Each of the cylinders is a separate casting, and the steam passages are formed by pipes external to the cylinders. In the connection between the high-pressure and the first intermediate is placed a reheater, into which live steam will be introduced for the purpose of restoring part of the heat lost by condensation in passing through the high-pressure cylinder. This heater consists of a wrought-iron shell containing a large number of seamless-drawn brass tubes.

Steam will be supplied by three Scotch-type boilers at 230 pounds per square inch working pressure, the battery being fitted with the Ellis & Eaves system of induced draft. Boilers are 12 feet diameter by 10 feet 6 inches long over heads, each containing three corrugated furnaces 36 inches inside diameter. The *Holden* will carry about 5,500 tons on the regular mean lake draught at the shoalest places. She will be ready for business August 1.—"Marine Record."

S. F. B. Morse.—There was launched at the Wheeler shipyard at West Bay City, July 31, the steamer *Samuel F. B. Morse*, building for the Bessemer Steamship Co., and the largest freight-carrying steamer on the Great Lakes. The launch was characterized by no ceremony of any kind. It had been planned for the afternoon previous, but an unavoidable delay gave opportunity for the grease on the ways to dry, so that when it was attempted to launch her the steamer could not be moved, and even the employment of hydraulic jacks proved ineffectual. The *Samuel F. B. Morse*, which has attracted much attention by reason of her superior size and the expectation that she will break all known cargo records for the lakes when she goes into commission, is 476 feet over all, 456 feet keel, 50 feet beam and 29 feet deep.

Probably the most distinctive characteristic of the vessel is the exceptionally heavy construction throughout. Her displacement on a draught of 17 feet will be 10,500 tons. The engines, which were built by Wheeler & Co., are quadruple expansion, with cylinders 26½, 37, 54½ and 89 inches by 42-inch stroke. The four Scotch boilers, which were manufactured by Wickes Bros., of East Saginaw, Mich., are each 13 feet 4 inches in diameter by 11 feet 6 inches long, with a steam pressure of 200 pounds per square inch.

The vessel has fourteen hatches, two smokestacks and two steel masts. The *Morse* is fitted with steam-steering gear furnished by the Globe Iron Works Co., of Cleveland; steam windlass and deck engines by the American Ship Windlass Co., of Providence, R. I.; pumps by Dean Bros., of Indianapolis, Ind.; and a very complete electric-lighting plant by the General Electric Co., of New York. The steamer has the usual accommodations for the crew, all in deck houses. The unforeseen conditions governing her construction make it impossible to give an approximate estimate of the cost, although the original estimate was in the neighborhood of $250,000.—"Marine Review."

Winifred.—The new steamship *Winifred*, launched early in July, at the Bath Iron Works, is an important steamer, in that she is the first American vessel of the "tramp" class ever built, and is undoubtedly the first of a long line of this style of cargo boat which the necessities of modern carrying will cause to be constructed in United States shipyards. The *Winifred* is 305 feet long over all; beam, 42 feet, and depth of hold, 25 feet. Her gross tonnage is 2,600, and her net tonnage 1,750. She has a grain space of 180,000 cubic feet and a bunker capacity of 420 tons. The vessel is to be fitted with a triple-expansion engine, supplied with steam from two Scotch boilers sufficient to develop power to give her a speed of 10 knots an hour under favorable conditions when loaded. The *Winifred* has a double bottom for water ballast. Four large cargo hatches, two pole masts carrying small steadying sails, steam windlass, steam-steering gear and four steam winches are other features of the new craft. In

many respects she is superior to vessels of the tramp type, and she is expected to more than hold her own with foreign carriers.

Steamer for Welland Canal.—The Bertram Engine Works Co. of Toronto has just closed a contract for the building of a grain carrier for the St. Lawrence & Chicago Steam Navigation Co., Limited, of Toronto, the former owners of the steamer *Rosedale*. The new steamer is to be full Welland Canal size, and to have all the latest improvements known to make it a thorough business vessel for the grain trade. Dimensions of hull will be 256 feet over all, 43 feet beam and 24 feet deep. Engines will be triple expansion, with cylinders of 17, 28 and 47 inches diameter and 36-inch stroke. The boiler will be of Scotch type, 13 feet 4 inches diameter and 11 feet 6 inches over heads, built for 170 pounds steam pressure, and to be fitted with Howden hot draft. A small donkey boiler, also of Scotch type, will be furnished. It is understood that this steamer will cost $125,000.

Tennessee.—The handsome new passenger propeller, *Tennessee*, built for the Old Bay Line, of Baltimore, for service on Chesapeake Bay, was successfully launched from the shipyard of the Harlan & Hollingsworth Company on July 9th. The new boat has a steel hull, and is of the following dimensions: Length, 245 feet; beam, 38 feet; depth, 15 feet; mean draught, 10 feet. Twin screws of manganese-bronze will be driven by two triple-expansion engines, having cylinders of 18, 38 and 45 inches, with a stroke of 30 inches, and steam will be furnished by four boilers of the Scotch type, 11 feet in diameter and 11½ feet long, having a working pressure of 160 pounds. She will have steam-steering gear and a powerful dynamo. She will be ready for service on September 1.

Toronto.—There was successfully launched, on Tuesday, June 21st, from the yards of the Bertram Engine Works Co., Toronto, the side-wheel steamer *Toronto*, built to the order of the Richelieu & Ontario Navigation Co.

The *Toronto* is constructed of open-hearth steel and her dimensions are as follows: Length over all, 278 feet; length keel, 270 feet; beam, moulded, 36 feet; beam, over guards, 62 feet; depth, moulded, 14 feet. The engines are of the triple-expan-

sion, inclined, jet-condensing type, diameter of cylinders, 28, 44, 74 by 72 inches stroke. The feathering paddle wheels are 22 feet outside diameter and 10 feet 3 inches face of bucket. The pumps are attached to and worked from the main engine.

The boilers are four in number, of the return-tubular type, 11 feet in diameter and 11 feet 6 inches long, designed for a working pressure of 175 pounds.,

The interior fittings of the *Toronto* will be of the most expensive and elaborate nature. There are to be 140 state rooms, including four parlor rooms, and a large Pullman sleeping cabin, furnishing sleeping accommodations for 430 passengers. The dining room is to be placed on an upper deck, and will have a seating capacity for over 100 persons.

The interior finish and decorations of spacious halls and deck saloons will be most elaborately executed, the main gallery saloons being finished in Francis I. Renaissance, with the dining rooms in Louis XVI. The entrance hall is decorated in Neo-Grec, with modern Renaissance details, with the smoking room in Oriental treatment. The refreshment and writing rooms will be in Elizabeth paneling of prima verba, natural-wood finish. The main staircases are in Honduras mahogany, with wrought-metal balustrades in hammered leaf work and finished antique bronze, the main newels carrying bronze figures supporting electric torches.

All the rooms and apartments particularly subject to heat are to be provided with a system of artificial ventilation, and a 700-light electric-light plant, with ornamental electroliers in the cabins, furnishes light throughout the steamer. Estimated total cost, $275,000.

New French Steamers for the English Channel Service.—As is well known, the Northern Railway Company of France is improving the passenger service between Calais and Paris. The train speeds have been considerably increased by means of the high-speed compound locomotives which we described recently. Supplementing this arrangement, and acting in harmony with the London, Chatham and Dover Railway Company, the Northern Railway of France is about to place on the Channel

service, some new high-speed steamers. The postal arrangements between France and Great Britain have until the present time been assured by a day and night boat between Dover and Calais. The mails were carried by the Chatham and Dover and the South Eastern Railway Companies, the day service being subventioned by the French Government to the extent of £4,000 per annum, while the night service was assured by an English subsidy of £25,200, a large part of which was paid for weekly transport of the Indian mails. At the time when the agreement between the French Government and the English companies was about to expire, the exact date being September 30, 1896, the French Chamber expressed the wish that the postal service should be entrusted to French hands, although no complaints had ever been made against the English contractors. Until 1855 this postal service had been, like many others at the same date, worked directly by the State, with the natural result that it was very expensive. It was than conceded for 15 years to a syndicate represented by a Frenchman and by an Englishman, Mr. Churchward, subject to an annual subsidy of £7,600, for which one daily service was to be performed; this syndicate entrusted the concession to the two English railway companies, and the arrangement continued in force until 1872. The term of the agreement having then expired, the French Administration conceded the service to Messrs. Dumont and Magnier for £4,000 per annum. These gentlemen sold their concession to the South Eastern and the London, Chatham and Dover Railways, with the modification that three of the steamers had to fly the French flag, first as the property of the financial company called the Société Générale, and afterwards of the Northern of France Railway Company.

In 1896, when the second contract terminated, the desire to prevent a renewal passing into the hands of this country was very marked in France, especially on the part of the French Chamber of Commerce, and it was unanimously felt that the concessionaires should be, and should remain, entirely French. Effect was given to this sentiment, and the Northern Railway of France fortunately obtained the concession, which could not

have passed into better hands, or of any company possessing such facilities for the proper performance of the service. This concession, which was granted after competition, was definitely approved by the French Chamber in June, 1896. As the Northern Railway of France had to build new boats to fulfil its contract, and as there was not sufficient time before the expiration of the old postal treaty with the English companies to do this, it made a temporary arrangement with the latter to maintain the service until the new boats should be completed.

A *rèsumé* of the conditions under which the new concession exists will be of interest. The treaty will expire on September 30, 1906, but it may be terminated before that date on a year's previous notice, or in the unlikely event of some new means of communication, such as a bridge or tunnel, being established between Calais and Dover. This latter route was preferred in preference to that of Dieppe and Newhaven or Boulogne-Folkestone, partly because it is the shortest and easiest sea route, but chiefly because a postal convention was completed in August, 1890, between France and Great Britain, obliging each Power to maintain a daily service between Calais and Dover.

The new steamers will be obliged to have a minimum speed of 15 knots as a yearly average. This does not appear high, but besides the fact of delays caused inevitably by distress of weather and other causes, which will lower the yearly average, the enterprise of the Northern of France Railway Company will certainly result in every effort being made to run their vessels at as high a speed as possible. The new ships will, of course, fly the French flag; they are, in fact, to be essentially French; all heavy repairs and renewals of boilers must be made in France; and French coal must be used, subject to conditions of price and quality. If foreign coal be employed, the concessionaires will be obliged to justify their breach of patriotism by proving absolutely that money is saved thereby. The two steamers which the Northern Company intend for the new service are now finished and will shortly be running, so that the present is an opportune time to publish some description of the type, which has many points of interest.

As a matter of necessity, they are side-wheel steamers, and

have been constructed by the Société des Ateliers et Chantiers de la Loire. The principal dimensions are as follows: Length between perpendiculars, 103 meters (338 feet); beam, 10.60 meters (34 feet 9 inches); width, outside paddle boxes, 20.80 meters (68 feet 3 inches); depth of hull below normal water line, 2.75 meters (9 feet ¼ inch); depth of hull, 4.95 meters (16 feet 3 inches); tonnage, 1,700. The steamers are ranked A1 Bureau Veritas. The hull is entirely of soft steel, and has a main deck with a promenade deck above and a partial lower deck. There are two rudders, one aft, of the usual type, and the other forward, arranged so as not to interfere with the general profile of the hull. The latter is divided by nine water-tight transverse bulkheads rising as high as the main deck, and assuring the flotation of the ship in the event of two adjoining compartments being filled with water. Further measures of safety are taken by adding six life-boats to the equipment of each steamer, and a number of life-belts equivalent to the maximum crew and the number of passengers carried. This total is 390 first, and 260 second-class.

On the upper, or promenade deck, only such superstructures are allowed as are necessary in order that the first-class passenger may have as much free space as possible. Forward of the funnels is the captain's bridge and all the necessary apparatus for communicating with the engine room and the wheel house. The various plans, which we publish on our two-page plate, show the general arrangements on this and on the other decks. Beyond the stairways which lead to the promenade deck and those going to the ladies' saloon is a series of well-fitted private cabins as well as two special state rooms separated from each other by a movable partition, as is done in the state cabins of the newer London, Chatham and Dover boats. On the new French steamers these state cabins are provided with beds; the stairway leading to the first-class saloon is placed aft, and the smoking room is still further aft. Structures on each side of the paddle wheels accommodate the crew, stewardesses, &c.; the lavatories and kitchens are also placed here.

Passengers can come on board the ship either by the main or by the promenade deck, according to the height of the tide. A

very excellent arrangement has been made for dealing with passengers' luggage; in the baggage hold are 16 large cases arranged in two tiers, and each able to hold one ton of baggage; these cases will be loaded prior to departure, and hoisted from the hold on arrival, where they will be deposited upon trucks on the quay by means of electric cranes of 5-ton capacity and a range of 14 meters (46 feet). It must, however, be borne in mind that a certain amount of the time thus gained will afterwards be lost in transferring the baggage from the cases to the passenger vans on the trains, and in sorting them for the Customs inspection.

The engines on these ships are specified to develop 7,000 horse power and to give a speed of 21.5 knots. They are triple-expansion with three inclined cylinders driving direct on the wheel shaft by three cranks set at an angle of 120 degrees. The diameters of the cylinders are respectively, 1.050 meters, 1.5 meters and 2.2 meters (42.34 inches, 59.06 inches and 86.61 inches), with a stroke of 2.250 meters (88.58 inches); these cylinders are steam jacketed and have a circulation of live steam from the boilers; the steam chests are cast in one with the cylinders; the valves are cylindrical and are four in number, the low-pressure cylinder having two; they are packed with cast-iron segments held out by springs. The valve gear, of the Stephenson type, is controlled by a special starting engine, and valves are provided to admit live steam on both sides of the low-pressure piston. Besides the main engine there is a circulating apparatus, consisting of two centrifugal pumps coupled on the same shafts and driven by a two-cylinder engine; there is a steam pump with a capacity of about 7,500 gallons per hour, which can draw either from the interior of the ship or from the sea.

There is also a special steam-steering gear controlling the port wheel; a feed-water heater fed by a special steam pump, and a dynamo driven by a Laval 30-horse power turbine for the electric lighting; this will be very liberally distributed throughout the ship in the form of incandescent lights, while on the bridge there will be four lamps of 50 candles, with reflectors for lighting the promenade deck on entering and leaving port; the signal lamps will also be electric. The double-circulation sur-

face condenser is placed transversely on the cylinders; the circulating tubes have an outside area of 700 square meters (7,540 square feet).

The main shaft is in three parts, connected by discs and bolts; it is made of soft steel, and the parts are interchangeable, the outside diameter of the shaft is 480 millimeters (18.90 inches); it, as well as the crank pins, are drilled with a hole 200 millimeters (7.87 inches) diameter. The shafts on which the wheels are mounted pass under the main deck. As to the wheels themselves, they are 6.90 meters (22 feet 7 inches) in diameter with nine paddles, 4.30 meters (14 feet 1 inch) long and 1.30 meters (51 inches) wide; the center through which the shaft passes, as well as all the framework of the wheel, is of steel, and the paddles themselves are of steel plate slightly curved and stiffened by cover plates; the connections of the paddles with the framing are of bronze.

The engines, which will run at a speed of 52 revolutions, are built upon steel foundation plates attached to the hull of the ship. There is a series of water-tube boilers of the Lagrafel and D'Allest type; forward there are two double groups of eight boilers, and aft there are two groups of four boilers; the former is separated from the latter by the coal bunkers, as will be seen by reference to our engravings, and by the water-tight bulkhead doors, which are operated from the main decks. The aft stokehold can communicate with the engine room by means of water-tight doors and by a passage from the main deck.

The ventilation of the boiler rooms and the forced draft are obtained by means of two steam ventilators placed in a compartment at the forward end of the engine room; these fans ventilate the engine room at the same time as they deliver air into the stokehold by means of conduits closed by regulating valves. This arrangement has the advantage of not delivering the air too cold into the stokehold. The discharge of each of the two fans is 80,000 cubic meters (2,820,000 cubic feet) per hour, for a combustion of fuel per square meter of grate and per hour not exceeding 135 kilogrammes at maximum power (27.6 pounds per square foot).

The boilers are registered to work at 13 kilogrammes (186 pounds per square inch); their grate surface is 48 square meters (516 square feet), and their heating surface in contact with the hot gases is 1,500 square meters; each boiler is fitted with the usual safety devices, blowing-off valves, etc.; any one of the boilers can be cut off from the others. Steam is collected in two steel collectors from the two groups of boilers, and they are connected by pipes provided with stop valves, and operated in case of necessity from the main deck. The boilers are fed by three steam pumps placed in the stokehold, two of them being forward; their capacity is 30 tons per hour. The smoke uptakes between the boilers are, like the funnels, made with a double envelope; they are led to a chamber forming the base of the funnel, which is oval in section and 17 meters (55 feet 9 inches) high above the grates.

The public will watch with interest the placing of these two vessels on the service, to which they will undoubtedly be a welcome addition. The credit for their design is due to Mr. DuBousquet, Ingénieur-en-Chef du Matériel et de la Traction, and to Mr. E. Sartiaux, who has designed the whole of the electric installation. We shall, on the earliest occasion, publish a report of the steam trials of these new boats.—"Engineering."

Twin-Screw Steamer Kaiser Friedrich.—[Partial descriptions of this vessel have been given in the last two volumes of the JOURNAL.] This magnificent, new, fast, twin-screw, express steamer left Bremen for New York on June 7, on her maiden voyage. She was built by F. Schichau, of Elbing, Dantzig, Prussia, for the North German Lloyd Line. The other great ship of the line, the *Kaiser Wilhelm der Grosse*, was built at the Vulcan Works in Stettin, Germany, so the new steamer's performance will be watched with keen interest by the ship and marine engine builders of both Europe and America.

The *Kaiser Friedrich* is 600 feet in length over all, 64 feet in breadth, and has a depth of 41 feet from the keel to the underside of the upper deck; her gross tonnage is 12,000, and her displacement, when laden to a draught of 28 feet, will be 17,000 tons. Ship and engines have been constructed according to the

highest requirements of the Germanischer Lloyd, and the vessel being a four-decker, extra strengthening has been applied. She has a double bottom running from end to end, and is divided into 18 water-tight compartments by 17 water-tight bulkheads, of which 15 reach to the upper deck, and two to the main deck. Any three adjoining compartments could be filled without the ship being endangered. The pumping arrangements in connection with this division of bulkheads are carried out with the greatest care, being so placed that each compartment can be pumped clear in a very short time by several pumps working simultaneously. She carries 22 life boats. As in the case of the *Kaiser Wilhelm*, provision has been made so that in case of war the ship can be used as an auxiliary cruiser.

Of deck structures the vessel has a forecastle 120 feet in length, and a midship erection which, together with the poop, extends to 444 feet. Amidships is a roomy deck house 300 feet in length, and over the promenade and deck house is a deck the whole width of the ship, thus forming a permanent awning for the first-class promenade deck.

The arrangements for the accommodation of the passengers and crew are similar to those on board the *Kaiser Wilhelm*. The seamen's quarters are forward. Abaft them are berths, both on the main and lower decks, for 750 steerage passengers. The whole midship portion of the steamer is reserved for the first-cabin passengers, and the after part for the second-cabin passengers. Nearly all the first-class sleeping cabins and most of the second-class are in the deck structures above the upper deck, where the ports can be kept open in almost any weather. This arrangement of berthing insures the most important advantage, that at night time and in foggy weather all the necessary openings in the bulkheads below deck can be kept closed without materially interfering with the free movements of the passengers.

For the first-class, there are in all about 180 sleeping cabins, to hold, together, about 350 passengers, most of these cabins consisting of "Pullman" rooms, which have lately become so popular, as they are so roomy during the day, being then sitting rooms; and there are also a good number fitted up in a princely

style, whole suites consisting of sitting room, sleeping rooms and bath and toilet rooms. The first-class dining saloon is on the main deck amidships. For the accommodation of second-class passengers there are 111 cabins, and most of these will be fitted to contain, each, only two persons.

The crew of this great steamer will consist of 400 hands, 180 being for the engines alone. The whole of the latter personnel will be berthed in the immediate neighborhood of the engine rooms. Great care has been bestowed upon the comfort of these men; the stokers and coal trimmers will have a mess room to themselves. The greater part of an awning deck has been set apart for their use, where, after their hard labor below, they can enjoy the fresh sea breeze in any weather. The officers have their comfortable quarters on the promenade deck.

The engines, which possess several features of interest, have been constructed at the works of Schichau, in Elbing, now under the sole management of Mr. Ziese, of that firm. The vessel has two sets of quadruple-expansion engines of, together, 25,000 horse power indicated, driving two three-bladed propellers of 20 feet 4 inches in diameter. They are of bronze. To insure a better trim of the ship, and for the purpose of avoiding vibration as much as possible, the engines have been placed, not in the after part of the ship, as has hitherto been the general custom on ships of this class, but amidships, an innovation adopted for the first time in the merchant service. Abaft the engines there is a boiler compartment. Each of the two engines has five steam cylinders acting upon three cranks, and they have been constructed of the best material, to insure the greatest efficiency combined with lightness. The crank and propeller shafts are made of Krupp's nickel steel. The diameters of the cylinders are as follows: high-pressure cylinder, 43¼ inches; first intermediate-pressure cylinder, 64¼ inches; second intermediate-pressure cylinder, 92⅛ inches; and two low-pressure cylinders of 93¼ inches each.

For the generation of steam at a pressure of 225 pounds there are nine cylindrical double-ended boilers, and one single-ended boiler, placed in three groups each arranged in a separate water-

tight compartment. The total heating surface is 73,000 square feet. The boilers are worked with Howden's system of forced draft. Owing to the adoption of the novel arrangement already referred to, of placing the engines amidships instead of in the after part of the ship, it became necessary to place one of the three boiler groups abaft the engine room, an arrangement well-known on torpedo boats, but never yet introduced on a large passenger steamer. Much interest will be taken in the results of this experiment. The ship has three funnels, equidistant from each other, and her fine lines will enable her to have high speed. —"American Shipbuilder."

Considerable disappointment was occasioned by the showing made by the *Kaiser Friederich*, the new twin-screw express steamship of the North German Lloyd Co., which arrived in New York June 16 from Bremen and Southampton, on her maiden trip, after a very slow run of 7 days 10 hours and 30 minutes. Her daily runs were 290, 406, 442, 395, 472, 378, 460 and 320 knots to Sandy Hook lightship, making a total distance of 3,163 knots; average speed per hour, 17.74 knots. The engines were stopped five or six times during the passage, owing to the failure of the circulating pumps to work properly, and to the overheating of various parts of the machinery. It is said that the vessel was not given sufficient preparation for the voyage. There was, of course, no opportunity to judge of the steamer's speed or make comparisons with the *Kaiser Wilhelm der Grosse*, as she could not be run at her best for any length of time.—" Marine Review."

New Trans-Atlantic Steamers.—The Vulcan Co., of Stettin, has secured the order for a new Atlantic steamer for the Hamburg-American Co. to excel in speed every liner afloat, the trial-trip speed guaranteed being 23½ knots on the measured mile, and 23 knots on the Atlantic. The vessel will be between 680 and 690 feet long over all, but the new White Star liner *Oceanic*, now building, is 704 feet over all. The North German Lloyd ship *Kaiser Wilhelm der Grosse* is 625 feet, and her consort, *Kaiser Friedrich*, 580 feet. The *Campania* and *Lucania* are 622 feet long. The breadth, however, will not be much greater than

these ships, being 66 feet 6 inches, while the *Kaiser Wilhelm der Grosse*, although over 60 feet less in length, is only 6 inches less beam. The new ship is therefore exceptionally long for her breadth. The twin-screw engines, which are to develop a collective horse power of 36,000 indicated, are to be of the quadruple-expansion type. The two low-pressure cylinders will drive the second and third cranks, the forward and after crank being actuated by tandem cylinders. This arrangement, it is believed, will give the best balancing arrangement, and the least twisting strain on the crank shaft. The boiler installation will not differ materially from that in the *Kaiser Wilhelm der Grosse*, which was built by the same firm at Stettin, but for the competing company, the North German Lloyd. There are in her twelve double-ended and two single-ended boilers, but the boilers in the new ship will be worked under Howden's system or Ellis and Eaves' design of forced draft.

The North German Lloyd and Hamburg-American jointly have also ordered four new twin-screw steamers to be built at the Vulcan Co.'s Works at Stettin, to be about 500 feet long between perpendiculars, or about 520 feet over all, and of 60 feet breadth of beam. They will each be fitted with two sets of four-crank quadruple-expansion engines, and three double-ended and three single-ended boilers, to develop 7,000 indicated horse power under ordinary conditions, which will give them a speed of 15 knots. They will, however, be fitted with a system of induced draft, which, when brought into requisition, will enable the engines to develop 9,000 indicated horse power, giving a speed of 16½ knots, which will be of great advantage for merchant work.

Galtee More.—Messrs. William Denny and Brothers, Dumbarton, launched on the 24th May the twin-screw steamer *Galtee More*, built for the London and North-Western Railway service between Holyhead and Greenore, for which the firm supplied formerly the *Rosstrevor* and *Connemara*. The new steamer is 280 feet long on the load-water line, 35 feet moulded breadth, and 15 feet moulded depth to the main deck. She has very fine lines, one peculiarity being the manner in which the run of the

ship is carried right out to the back of the rudder. The shafts for the twin screws are enclosed in webs, built out from the side of the ship, the ends of the shafts being supported by a "spectacle frame." She has also large bilge keels to minimize rolling. Much accommodation is provided for both saloon and steerage passengers. The first-class saloon is situated on the main deck, forward of the boilers. On the port side abaft the saloon there is a large ladies' room, and adjoining this there is a suite of state rooms reserved for ladies. On the opposite side there is a range of state rooms reserved for gentlemen. On the lower deck there is a large sleeping saloon, fitted all round with sofas. The third-class accommodation is situated aft on the main and lower decks. The officers and engineers are berthed on the bridge deck, and above the dining saloon there is a roomy companion, with a few special state rooms. The vessel has two pole masts, and will be fitted with four-crank engines and high-pressure boilers by Messrs. Denny and Co. She is fitted throughout with electric light, and has also a complete system of mechanical ventilation driven by electric fans. She has very large accommodation for carrying cattle, which is an important feature in the Greenore trade.

Ultonia.—Messrs. C. S. Swan and Hunter, Limited, Wallsend-on-Tyne, launched on June 6th the twin-screw steamer *Ultonia*, built for the Cunard Steam Shipping Company, of Liverpool, for their Boston service. This vessel is the largest that has yet been built on the North-East Coast, being of the following dimensions: Length over all, 513 feet; breadth, 57 feet 4 inches; and depth moulded to shelter deck, 44 feet 11½ inches. The vessel has a shelter deck, all fore and aft, over which is a long bridge, 140 feet in length, both being fitted with the latest designs of stalls for the carriage of a large number of cattle. The whole of the space in the lower 'tween decks forward has been insulated to carry chilled beef, three large refrigerating machines being placed at the fore end of the bridge. These machines are on the latest ammonia principle, and are being fitted, together with the insulation, by the Liverpool Refrigerating Company.

The officers, engineers and petty officers are accommodated

in a large deck house, containing captain's room, chart room and wheel house. The crew are berthed forward in the forecastle, and a number of cattlemen in the poop. The vessel is rigged as a four-masted fore-and-aft schooner, and will have a large number of powerful winches and derricks for rapid loading and discharging. The engines are of the twin-screw triple-expansion type, and built by Sir Christopher Furness, Westgarth and Co., Limited, of Middlesbrough, the cylinders being 23½ inches, 38½ inches and 68 inches diameter, with a stroke of 48 inches. The boilers are five in number, single-ended, 14 feet 4½ inches diameter by 12 feet long, each having three furnaces. These engines are expected to give the vessel a speed of 13 knots in the Atlantic when the vessel is fully loaded with a cargo of 11,000 tons.

Monmouth.—The steamship *Monmouth* is another of the new mammoth freight carriers that have been built recently by Harland & Wolff, Belfast, Ireland. Her measurement is, tonnage, net, 6,118, gross, 8,000; length, 504 feet; beam, 56 feet; depth of hold, 42 feet; dead-weight cargo capacity, 12,000 tons, and she is expected to store something over 28,000 bales of cotton with other cargo. The *Monmouth* is a twin-screw vessel, with modern engines, steam-steering gear, and all modern improvements have been added to her machinery. Horse power, nominal, 530, and indicated, 3,600. On her main deck fittings have been placed which will enable her to carry in addition to other cargo 600 head of cattle with perfect safety.

A Gigantic Russian Ice Crusher.—The fact that representatives of the Russian Government visited the United States to inspect the ice crushers in use on the Lakes, and that officials of the Detroit Dry Dock Co. went to St. Petersburg for a conference on the same subject, lends interest, on the part of lake marine men, to the gigantic ice crusher which the Russian Government is now having constructed in England. The vessel is intended for use in keeping an open navigable way during winter to Cronstadt and St. Petersburg, and in summer is to be stationed in the Kara Sea, to keep open a way for vessels trading with North Siberia. Some idea of the magnitude of the crusher now

building may be gained when it is stated that at present the most powerful vessel of this type in existence is the *Nadeschny*, stationed at the port of Vladivostock in Russia. Her cost was $225,000, and she is provided with engines of 3,600 horse power, which enabled her, at her trial last year in the Gulf of Finland, to force her way through ice very much thicker than that which is encountered in the Straits of Mackinac by the vessels built at Detroit. The vessel now in course of construction, however, will have engines of 10,000 indicated horse power and will cost $875,000. She will not only have a double bottom throughout her whole length of 305 feet, but will also be provided with a double skin up to a few feet above the water line, with a space of about 3 feet between the skins. She will have four sets of engines of a special make, one set being located forward for working a plurality of screw propellers, and the other three will be placed aft and connected with three screws. Bunkers will be provided for 5,000 tons of coal, the daily consumption being about 161 tons. The vessel is to be finished by the end of the year, and should her trial trip prove successful, the keel will immediately be laid for a sister ship.

Kasuga Maru.—The new steamship *Kasuga Maru*, built by Messrs. R. Napier and Sons, Limited, for the Nippon Yullu Kaisha (Japan Mail Steamship Company), has completed a series of speed and consumption trials on the Firth of Clyde, and has fully satisfied all the conditions of the contract. The *Kasuga Maru* is the first of three steel screw steamers the builders have on hand for the company, and has been specially designed to meet the requirements of their Japan and Australian service. The general dimensions are: Length, 375 feet; breadth, 44 feet; depth, 27.8 feet; with a topgallant forecastle, long bridge, full poop and partial shade deck, and constructed with a cellular double bottom for water ballast. Accommodation has been provided amidships for the first-class passengers, and as the steamers are intended to trade in tropical climates, the commodious state rooms have been placed on the upper deck, which admits of perfect ventilation, and are furnished with the latest improvements for the comfort of the passengers. Above, on the

bridge deck, are dining saloon, music room and smoking room, in polished oak, and fitted with swivel side lights, electric fans, etc., the ventilating arrangements having had special attention. Overhead the boat deck forms an admirable shelter to the spacious promenade on the bridge, and on it are situated the chart room, captain's and officers' cabins. The second-class accommodation (scarcely inferior to the first) is in the poop, with a large dining saloon, comfortable smoking room and roomy state rooms; while spacious quarters for emigrants are in the 'tween decks. The machinery consists of a set of triple-expansion engines, having cylinders 29 inches, 48 inches and 79 inches in diameter by 54 inches stroke, with two double and one single-ended boilers for a working pressure of 185 pounds.

Hong-Kong Maru.—The twin-screw liner *Hong-Kong Maru*, was successfully launched on the 7th of July from the shipyard of Sir James Laing at Sunderland. The vessel has been built to the order of the Oriental Steamship Company of Japan (Tojo Kisen Kabushiki Kaisha of Tokio), and is the second ship built by Sir James Laing for that company, and is intended for fast passenger and cargo service between China, Japan and the United States. Her dimensions are: Length, 431 feet; breadth, 50 feet 6 inches; depth moulded to upper deck, 32 feet 6 inches. The vessel has been constructed of steel throughout, under the supervision of Messrs. Flannery, Baggallay and Johnson, of London and Liverpool, to Lloyd's highest class, as well as to the rules of the Imperial Japanese Government and the British Board of Trade. Accommodation has been provided for a large number of first-class and second-class passengers, and about 250 emigrants. The first-class accommodation consists of special suites, a luxurious saloon capable of seating all the first-class passengers at one time, spacious social hall, and tastefully decorated ladies' and smoking rooms. The second-class passengers are also accommodated in a similar manner. Electric light has been fitted throughout, and ample and efficient ventilation is arranged for, as well as a complete system of heating during the cold weather. There is space in the holds for about 5,000 tons of cargo. The engines, which are built by Messrs. George Clark, Limited, of

Sunderland, have been designed with a view to the high speed on service of nearly 17 knots, and have cylinders 28¼ inches, 46 inches and 75 inches in diameter, with a stroke of 48 inches, taking steam from four double-ended and one single-ended boilers.

Trigonia.—On Wednesday, the 8th of June, the steamship *Trigonia*, which is being constructed to the order of Messrs. M. Samuel and Co., of London, for the carriage of bulk-oil cargo in the East, was launched by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, from their Walker shipyard. Like her sister ship *Haliotis*, the *Trigonia* has been constructed under the supervision of Messrs. Flannery, Baggallay and Johnson, of London and Liverpool, and she is 248 feet 6 inches over all and 40 feet moulded. As is the almost universal custom for vessels engaged in this trade, the *Trigonia* is fitted throughout with a very complete electric-light installation, and has an ample pumping plant of the duplex type, which is designed with a view of very prompt loading and discharge of her oil cargoes. The engines are of the compound surface-condensing type, having cylinders 30 inches and 63 inches in diameter with 39-inch stroke, and her two boilers are constructed for 100 pounds working pressure. As the vessel is intended to burn liquid fuel on her service, the bunkers have been specially designed and built to this end, but the furnace arrangements will also permit of coal fuel being used if needs be. Owing to the *Trigonia* being built on the turret-trunk system, she is expected to have a larger carrying capacity in proportion to registered tonnage than should be the case if designed on the ordinary system.

Chicago.—Messrs. Furness, Withy and Co., Limited, West Hartlepool, launched on May 7th the large steel screw-steamer *Chicago*, of 490 feet length over all, with a dead-weight carrying capacity of 8,500 tons, and a measurement capacity of about 12,000 tons. This vessel has been built to the order of Messrs. Thomas Wilson, Sons and Co., Limited, Hull, and is intended for their passenger, cattle and cargo trade. The vessel is built on the web-frame principle, with cellular double bottom for water ballast, with all the latest appliances for filling and discharg-

ing the tanks. The whole of the main framing is of strong sectional material, the topsides being as strong as any other portion. The hull is divided into nine compartments by means of eight water-tight bulkheads. There are nine large cargo hatches, and ten powerful steam winches by Clarke, Chapman and Co., and double derricks for the quick manipulation of cargo, three complete steel decks, and in addition a shade deck above with a bridge 130 feet long on top of it. Arrangements have been made for carrying over 800 head of cattle under the shade and bridge decks.

The vessel will be rigged as a four-masted fore-and-aft schooner. Accommodation for about eighteen first-class passengers is to be fitted in a large deck house on the bridge deck. Bath rooms, lavatories, electric bells, awnings, etc., will be fitted complete, to ensure the comfort of the passengers at sea. An installation of electric light will be fitted throughout the vessel on the double-wire system. A special feature of the installation is the use of armored flexible cable for the portable lights in the engine room and on deck, which will afford reliable protection against damage should the wires become twisted or left to chafe against the hatch coamings. The engines, which are being constructed by the Central Marine Engine Works, West Hartlepool, have been designed to suit the requirements of the heavy Atlantic trade. The diameters of the cylinders are 32 inches, 54 inches, 90 inches diameter by 66 inches stroke, on the three-crank, triple-expansion principle, with a steam pressure of 200 pounds per square inch, the cylinder supports consisting of massive cast-iron divided columns. The propeller is of the variable-pitch type, the blades being of manganese-bronze. Steam is supplied by two double and two single-ended boilers, the latter being in the center and arranged back to back, either serving as an auxiliary in port.

Prince George.—The Earle's Shipbuilding and Engineering Company, Limited, Hull, launched on the 21st May the high-speed twin-screw mail and passenger steamer *Prince George*, for the Dominion Atlantic Railway Company of Canada, being the second steamer built by Messrs. Earle for this company. The vessel is built under the shade-deck coasting class of Lloyd's

rules, with extra scantlings for special service, and is of the following dimensions: Length, 290 feet; breadth, 38 feet, and depth, 17 feet 3 inches. She has been constructed under the supervision of Messrs. Flannery, Bagallay and Johnson, of London, and has sleeping accommodations for nearly 340 first-class passengers, with handsome dining room, music room, ladies' boudoir, &c. She has also good accommodation for 44 second-class passengers. The vessel complies with the Board of Trade and American Law requirements for passenger service. She is fitted with twin-screw engines arranged for driving the vessel at a speed of nearly 20 knots on the trial trip. Steam is supplied by four large single-ended boilers worked under the closed-stokehold, forced-draft system, the fans being electrically driven.

Manchester City.—On Monday, the 6th of June, there was launched from the shipbuilding yard of Sir Raylton Dixon and Co., Limited, Middlesbrough, the Atlantic steamer *Manchester City*, for the Manchester Liners, Limited, of which Sir Christopher Furness is chairman. This company has recently been formed to run a line of large steamers direct from Manchester to Canadian ports, of which steamers this is the first one launched. Her particulars are as follows: Length over all, 461 feet, by 52 feet beam and 41 feet deep to upper deck, carrying a dead-weight cargo of 8,600 tons, and with a total measurement capacity of 14,500 tons. She has an exceptionally large quantity of water ballast in double bottom, and large chamber abaft the engines. At present she will be fitted for 700 cattle, and complete accomodation for the attendants. Very efficient ventilation is provided, and electric lighting throughout. Her triple-expansion engines, of about 4,000 indicated horse power, are by Sir Christopher Furness, Westgarth and Co., Limited, of Middlesbrough, and have cylinders 30 inches, 50 inches and 83 inches in diameter by 54 inches stroke, with four single-ended boilers, 14 feet 4½ inches in diameter by 12 feet long, 200 pounds pressure, and fitted with Howden's forced draft. The propeller will be of manganese-bronze. These engines, it is estimated, will give her a speed of over 12½ to 13 knots at sea.

Large Pontoon.—Messrs. Robert Stephenson and Co., Lim-

ited, Hebburn-on-Tyne, launched on the 21st of June a large steel derrick pontoon, built to the order of Messrs. W. Cory and Son, Limited, London. This pontoon, which is 500 feet long, 47 feet 6 inches extreme width, and 12 feet 6 inches moulded depth, is to be placed on the Thames for the discharging and loading of coal, and when finished will form one of the novel sights on that river. The pontoon, which is ship-shaped at the ends, with a poop at either end, has four lines of rails running nearly the entire length of the structure. On the outside, or stream side, on which the steam colliers are to lie, there are to be nine hydraulic grabs with weighing machines attached, running on one pair of rails. With these grabs the coal is to be taken out of the colliers (which can lie two at a time alongside), be weighed and the weight registered, and then swung round and discharged into nine chutes which travel on the other pair of rails. These shoot the coal into barges floating on the opposite side of the pontoon. These barges deliver the coal all round London wherever there is a waterway.

The pontoon is extensively subdivided into compartments, and has a double bottom throughout about two-thirds of its length. The hydraulic power is supplied by three large pumping engines, and a large accumulator is placed at each end. In addition to the nine hydraulic grabs there are six powerful hydraulic warping capstans and rollers for warping the barges into position. This hydraulic work is to be supplied by Messrs. Tannett, Walker and Co., of Leeds. Steam is supplied to the pumping engines, pumps, &c., by four large marine-type boilers. Powerful duplex ballast and bilge pumps are fitted for pumping from every compartment. Large charcoal filters are fitted for filtering the river water used in connection with the hydraulic plant, and the waste water from the cranes is filtered and returned to the main supply tank.

There is a complete set of workshops on board, so that all repairs can be attended to by the staff on board, such as carpenters' shop, smiths' shop, platers' shop, fitting shop, iron stores, wood stores, rope stores and general stores, occupying a large compartment. A large kitchen with range and grill, and sepa-

rate dining rooms are provided for the coalies, meters, engineers, lightermen, &c., and a handsome room is fitted up for the directors' meetings. There are also private cabins for the engineers and captain in charge.

The pontoon will be moored in the Thames by four large 2½-inch mooring chains at each end attached to specially constructed screw piles in the bed of the river, and special heavy cable stoppers, each weighing about 7 tons, are provided for fixing the chain on board. The whole derrick is lighted throughout with electric light, and the current for the lights on the grabs and chutes is taken off a traveler attached to the rails on which they travel. Portable cables are also provided for lighting the holds of vessels discharging alongside.

The pontoon has been built to the designs of Mr. H. Shoosmith, the company's engineer, and has been superintended during construction by him and his assistant, Mr. S. P. Coaker. The builders found it would be dangerous to launch such a long, shallow structure in the usual way, viz: in the direction of its length, and it was therefore laid down broadside on to the river and launched thus. The first plate of the bottom of this pontoon was placed on the blocks February 2, 1898, and the building of this large structure has therefore taken about 4½ months, which is a very creditable performance. The pontoon has been so designed that cranes of special construction are capable of lifting 7 tons each without producing an undue inclination of the vessel, and these will operate the grabs holding two tons of coal, and, with suitable ships, as much as 800 tons per hour will be weighed and transhipped from steamers to river lighters.

La Lorraine and La Savoie.—The Compagnie Générale Transatlantique is having built at St. Nazaire two new steamships which are to make 22 knots or more. They are to be known as *La Lorraine* and *La Savoie*, and each will cost about $3,000,000. The length will be 550 feet; beam, 58 feet, and depth of hold, 40 feet. There will be two engines, developing about 25,000 horse power, which will drive twin screws. It will be two years before these vessels will be completed. In anticipation of the building of these vessels the French senate on July

3 passed a bill awarding the mail contract between New York and France to the French line for ten years, dating from 1901, on condition that the steamships make fifty-two trips a year at an average speed of 20 knots. In 1903, it is planned, the French line will have another passenger and mail steamship of 23 knots' speed, and in 1905 a fourth vessel still faster.

Duke of Cornwall.—On Thursday, July 21, a trial was made of a cross-channel steamer, built by Messrs. Vickers, Sons and Maxim, to the order of the Lancashire and Yorkshire Railway and the London and North-Western Railway, for the Fleetwood and Belfast service.

The *Duke of Cornwall*, which is the name of the new vessel, is a twin-screw steamer, 325 feet 6 inches long over all, 37 feet beam, and has a moulded depth from the main deck of 17 feet 6 inches, and from the promenade deck of 25 feet 6 inches. The gross tonnage is 1,540 tons, and the net registered tonnage, 414½ tons. She has eight water-tight bulkheads, and is rigged as a fore-and-aft schooner, with two pole masts and the usual derricks. There is one funnel, 35 feet 8 inches high and 9 feet 6 inches in diameter.

The machinery consists of two sets of three stage compound engines of four cylinders each, the high-pressure cylinders being 22½ inches, the intermediate cylinders 34 inches, and the two low-pressure cylinders each 38½ inches in diameter, the stroke being 33 inches. The engines are balanced on the Yarrow-Schlick-Tweedy system. The low-pressure cylinders are placed respectively at the forward and after ends of the engines with the intermediate and high-pressure cylinders placed between them, and the cranks are set at angles in accordance with the system worked out by Messrs. Yarrow, Schlick and Tweedy. The result is stated by the engineering authorities of the purchasers of the vessel to be most satisfactory, the freedom from vibration when running at full speed being remarkable. We were unable to make the trip across to Ireland, but were on board during a run at moderate power, and certainly the engines worked so smoothly that it was difficult to say whether the ship was under way or not, when below.

The intermediate and high-pressure cylinders have piston valves, whilst the low-pressure cylinders have ordinary double-ported slide valves with a relief arrangement at the back. All these valves have the ordinary link motion and are placed between the cylinders in the usual way. Joy's "assistant cylinder," is fitted to the intermediate and low-pressure engines for balancing the weight of the valves. Hydraulic reversing gear is fitted, both engines being worked in the center of the central platform between the two sets. The framing is composed of cast-iron standards on one side and wrought-steel columns on the other; the bedplate being of box section with six main bearings. The air pumps are driven by side levers from the high-pressure crossheads. Cylindrical surface condensers are used, having a total cooling surface of 6,400 square feet, the circulating pumps being of the centrifugal type. The feed pumps are of the Weir type with automatic control. There is a feed heater and a "Rankine" filter. The propellers are of bronze and have each four blades, the diameter being 10 feet 6 inches.

There are four single-ended return-tube boilers, 15 feet 3 inches mean diameter and 11 feet long, each boiler having four Morison suspension furnaces. The total grate area is 317 square feet and the total heating surface 10,772 square feet. There is also an auxiliary boiler for electric-light engines, winches, &c., when in port. Two 6-foot fans are fitted for forced draft on the closed stokehold system.

The contract mean draught is 12 feet 8 inches, the maximum allowed being 13 feet 4 inches, at which the dead-weight capacity was to be 250 tons. These conditions have been fulfilled in practice.

In regard to general arrangements for passenger accommodation, etc., the *Duke of Cornwall* represents the best and most recent practice in regard to cross-channel steamers, and has accommodation for 412 saloon passengers and 388 steerage passengers.

On the trip from Fleetwood to Belfast and back of the 21st of July, the run out was made at a mean speed of 19.95 knots, and the return journey at 20.29 knots, the weather being fine. The

maximum speed for any one hour was 22 knots by log. The contract speed was 19½ knots. The revolutions averaged 163 per minute. The steam pressure was about 180 pounds, the average air pressure 1 inch on the water gauge, and horse power was estimated at about 6,000.

Regele Carol I.—The new twin-screw steamer *Regele Carol I*, which the Fairfield Shipbuilding and Engineering Company, Limited, have built for the Roumanian States Railways, ran her official trials on the 16th of June, in the Firth of Clyde. The trials consisted of six hours' steaming at full speed, with six runs over the measured mile at Skelmorlie. In the six runs a mean speed of 19 knots per hour was attained. This is considerably over the speed guaranteed by the builders. After running the mile the vessel steamed to Ailsa Craig and back to Gourock. The day was delightfully fine, and the cruise, both as a cruise and as a test of the ship's capabilities, was in every way a success. The new steamer is intended to open a new line from the Continent, which will connect directly from London and Paris, to Constantinople, and thence to Alexandria. The Roumanian Government started this service three years ago, and shortly afterwards bought an Italian vessel, which has since been running between Constanza and Constantinople. The success of the venture was such that the Government decided to extend the line to Alexandria, and the *Regele Carol I* is meant to take up this new work. Through communication direct from Paris and London will connect with the vessel at Constanza, after which there will be a fine voyage of twelve hours, passing through the beautiful scenery of the Bosphorus.

In anticipation of the reception of the King and Queen of Roumania at Bucharest, the vessel has been fitted out with a special installation of electric lights. About 300 lights have been placed all over the decks, carried from the bows right along the masts and sides, and throughout the dining saloons, where the Royal party will be received. These illuminations have been displayed for several nights back, as the vessel lay at the Tail of the Bank, and have been seen to fine advantage from both sides

of the firth. Special engines and dynamos have been placed on board for this temporary installation.

This vessel is fitted out internally in a most sumptuous style. On the shade deck is the music saloon, in satinwood, elaborately carved and gilded. The carving is a feature of this saloon, the work being all done out of solid wood. Adjoining the music saloon are two suites of apartments specially fitted for receiving the Royal party. They are in satinwood, with satinwood dado, white enameled walls and tapestry panels. On the main deck is the smoking room, which is fitted in mahogany, with satinwood panels and ceiling, and richly upholstered in morocco. The ladies' boudoir is also on the main deck. It is beautifully finished in *Louis XV* style. The first-class cabins are situated on the main and shade decks, the second class on the lower deck, but entered off the shade and main decks, with the main-deck entrance forming a comfortable lounge, and the third-class accommodation is situated aft in two large apartments. The first-class dining saloon is on the main deck. Her general dimensions, it may be added, are: Length, 365 feet; breadth, 42 feet 3 inches; depth, 29 feet 2 inches, and tonnage, 2,600 gross. Triple-expansion engines have been supplied by the builders.

New England.—On June 30th the *New England*, the latest addition to the Dominion Line, left Belfast for adjustment of compasses and trial trip. The *New England* has been built by Messrs. Harland & Wolff, of Belfast, and is expected to be one of the fastest liners between Liverpool and Boston. She is upwards of 565 feet long, and her gross register is nearly 12,000 tons. The ship is propelled by twin screws and triple-expansion engines on the builders' balanced four-cylinder system. The first and second-class accommodation, which is arranged on the four principal decks, for over five hundred passengers, is described as being "second to nothing afloat." The poop has been entirely set apart for the third-class passengers, and can accommodate nearly eight hundred. There is a dining room 80 feet in length and about 18 feet wide. The steerage passengers in this ship have also the benefit of a large and commodious smoking room, which they are able to enter from the dining

hall by a stairway; and the owners have further furnished a piano for the use of the steerage passengers.

Juno.—The new paddle steamer *Juno*, which has been built by the Clydebank Engineering and Shipbuilding Company, Limited, for the Glasgow and Southwestern Railway Company, ran her official trials on the Firth of Clyde recently. The vessel was run several times over the measured mile at Skelmorlie, and a mean speed of 19.26 knots per hour was obtained. Afterwards she proceeded down the firth on a four hours' run at the contract speed. The weather was somewhat disagreeable, but the vessel behaved splendidly all through the day. The new steamer, which is intended to take up the excursion service on the Ayr, Troon and southern section of the Firth of Clyde, is of 600 tons gross, 245 feet in length between perpendiculars, and 29 feet in breadth moulded.

There is accommodation on board for about 1,500 passengers of all classes. The first class are accommodated in the after end of the vessel, their dining saloon being seated for 100 persons. In the forward end are spacious apartments for the second class. The promenade deck extends practically the full length of the steamer, and affords fine accommodation for excursion parties. The engines are of the compound, diagonal, direct-acting type, of the usual Clydebank design. The diameter of the high-pressure cylinder is 33 inches, and that of the low-pressure 71 inches, with a stroke of 60 inches. The condenser is built up of steel plates, and the entablatures and frames are of cast steel, which insures the maximum of lightness with rigidity. Steam is supplied by one large, double-ended boiler of the usual marine type, designed to work at a pressure of 150 pounds per square inch, with eight furnaces. The forced draft is on the closed-stokehold principle, the air being supplied by two double-breasted fans of the builder's own make.

YACHTS.

Endion.—The Gas Engine and Power Co. and Chas. L. Seabury & Co., Consolidated, of Morris Heights, New York City, about May 15, completed the steam yacht *Endion* for Mr. Jesse M. Metcalf, of Providence, R. I.

The hull is of wood, yellow-pine planking and oak frames, with steel deck beams over the machinery space and a steel stringer and sheer strake running the entire length, connected by a steel angle. Steel gussets are used instead of knees for connecting the deck beams and frames. The length is 103 feet over all, 14 feet beam, 4 feet 9 inches draught, 8 feet depth and 52½ tons displacement. The dining room is in a deck house forward, and contains a table large enough to seat eight persons comfortably. From the dining room a stairway leads down into the quarters for the owner and guests, which consist of three state rooms and transoms for four in the saloon. The crew, consisting of a captain, engineer, fireman, cook and two deck hands, are quartered aft.

There is one Seabury water-tube boiler, type D, with feedwater heater in the uptake, having 23 square feet grate and 777 square feet heating surface. It has 456 tubes, 1 inch outside diameter, leading from the steam drum to the two water drums, six rows deep by thirty-eight rows long. The boiler casing is 68 inches wide, 80 inches long and 75 inches high, the height being measured from the bottom of the ash pan to the highest point of the casing. The smoke pipe is 22 inches diameter with an outer casing, 39 inches diameter, and the space between the two pipes serves as an uptake for the hot air from the engine room, and the escape pipe and whistle are led through it. The weight of the boiler without water is 8,600 pounds.

The engine is triple expansion, with cylinders 7 inches, 11¼ inches and 17½ inches diameter by 10 inches stroke, and is de-

signed to develop about 300 I.H.P. at 250 pounds steam pressure when making 450 revolutions per minute. The main valves are piston valves, without packing rings, and are worked by a valve shaft run by the main shaft through gear wheels. The diameter of the crank shaft is 3¼ inches, and the crank pins are 5 inches long. The cylinders are supported by eight 1⅜-inch steel columns well braced and tied. There is a keel condenser of about 70 square feet cooling surface. The air pump is 7½ inches diameter and 3 inches stroke, and is worked from the low-pressure crosshead; it rests on a seating cast on the engine bed plate. The thrust block is also cast on the engine bed plate. The weight of the engine is 3,050 pounds.

A trial on May 17, over a surveyed course on the Hudson River between Yonkers and Tarrytown, gave the following results: Steam pressure, 205 pounds; I.P. receiver, 65 pounds; L.P. receiver, 12 pounds; vacuum, 26 inches; revolutions, 366 per minute; speed, 15¼ miles per hour. A noticeable feature of the trial was the steadiness of the water level in the boiler at all times. The boiler formed steam freely, and no tendency to carry over water was observed. The machinery worked smoothly and quietly and was satisfactory in every respect.

Margaret.—This steam yacht was built by the same firm as the *Endion*, for Mr. John H. Rutherford of New York City, for use on Lake Champlain. Immediately after her trial her deck house, masts, etc., were taken down and she steamed up the Hudson to Albany, and will go through the Champlain Canal into Lake Champlain. The *Margaret* was launched on June 20, and, after a short dock trial on June 21, she was given a trial over a surveyed course on the Hudson River on June 22. This was not intended to be a full-speed trial, on account of the short time for preparation, so no great effort was made to develop the full power of the machinery. The average steam pressure was 210 pounds; vacuum, 24 to 26 inches; speed, 16.25 miles per hour for one and one-half hours. The engine worked without any tendency to heat except that the thrust bearing worked warm. After having run for a short time a speed of 17 miles per hour should be made.

The hull is of wood, yellow-pine planking, put on in two thicknesses above the water line, and oak frames. There are steel deck frames over the machinery space and a steel stringer and sheer strake runs the entire length, connected by a steel angle. Steel gussets are used instead of knees to connect the deck beams and frames. The length is 103 feet over all; 15 feet beam; 4 feet 9 inches draught; 8 feet depth, and 55 tons displacement. The dining room is in a deck house forward, and is large enough to seat eight persons comfortably. The crew's quarters are forward, and the owner's and guests' quarters, consisting of two double state rooms and four transom berths in the saloon, are aft.

There is one Seabury water-tube boiler, Type D, with feed-water heater in the uptake; it has 32.25 square feet grate surface and 950 square feet of heating surface. It has 528 tubes, 1 inch outside diameter, leading from the steam drum to the two water drums, six rows deep and $1\frac{1}{2}$ inches between centers, by forty-four rows long and 2 inches between centers. The steam drum is 21 inches in diameter, and the lower manifolds are made of the half of an 8-inch pipe with a $1\frac{3}{8}$-inch plate for the tubes. The boiler casing is 92 inches long, 76 inches wide and 80 inches high, the height including the ash pan. The smoke pipe is 25 inches in diameter, with an outer casing, 43 inches in diameter. The space between the pipes contains the escape pipe and whistle pipe and serves as an uptake for hot air from the engine room. The weight of the boiler complete without water is 10,880 pounds.

The features of the machinery particulary noticeable are the use of a keel condenser of new design and with large cooling surface, the accessibility of the working parts of the engine for adjustment and repairs, and the length of all the principal bearings. The engine is vertical, triple expansion, with cylinders $8\frac{1}{2}$ inches, 14 inches and 23 inches in diameter by 12 inches stroke, and is designed to develop 400 I.H.P. at 250 pounds pressure when making about 425 revolutions per minute. The main valves are piston valves without packing rings, and are worked by a valve shaft run by the main shaft through gear wheels. The diameter of the crank shaft is $4\frac{1}{2}$ inches and the crank pins

are $7\frac{1}{2}$ inches long. The cylinders are supported by eight $1\frac{1}{2}$-inch steel columns well braced and tied.

There is a keel condenser of about 200 square feet cooling surface. This keel condenser consists of two rows of ten $1\frac{7}{8}$-inch-diameter copper pipes. The ends of these two rows are joined near the center by a manifold to which the exhaust pipe is connected. The pipes are reduced to $1\frac{5}{16}$ inches in diameter for one foot at the forward and after ends, where they are connected by manifolds, to which the air pump suction pipes are led. The feed water was cool and the vacuum good at the highest speed at which the engine was run, showing that there was an excess of cooling surface. The air pump is worked from the L.P. crosshead, and is $9\frac{1}{2}$ inches in diameter and 4 inches stroke. The thrust block is cast with the main engine bed plate, and the thrust is taken on eight collars, $6\frac{1}{2}$ inches in diameter. Although the engines had been run but three hours before the trial, all parts ran very well, and all except the thrust bearing ran without water. The weight of the engine is 5,900 pounds.

Saranac.—The twin-screw naphtha-yacht *Saranac*, owned by Mr. George W. Quintard, of New York City, has undergone extensive alterations at the works of the Gas Engine & Power Co., and Chas. L. Seabury & Co., Consolidated, Morris Heights, New York City.

The two 16-horse power naphtha motors have been taken out, the length of the yacht has been increased from 76 to 95 feet, and two Seabury engines and one Seabury boiler now furnish the motive power. The owner's quarters are forward and the crew's abaft the machinery space. There is one Seabury water-tube boiler, type D, with feed-water heater in the uptake; with 14.77 square feet of grate surface, and 580 square feet of heating surface. There are 348 tubes, 1 inch outside diameter, twenty-nine rows long and six rows deep. The steam drum is 21 inches in diameter, and the water manifolds are made using a steel plate $1\frac{3}{8}$-inch thickness for the top, and the half of an 8-inch pipe for the bottom of the manifold. The boiler casing is 62 inches long, 56 inches wide and 72 inches high. The diameter of the smoke

pipe is 20½ inches and it has an outer casing. The weight of the boiler complete is 6,700 pounds.

The engines for the *Saranac* are compound, 4 inches and 8 inches in diameter and 7 inches stroke. Each is designed to develop 25 I.H.P. at full power, or when the engines are making 400 revolutions per minute. The valves are driven from eccentrics on the main shafts; the H.P. valve is a piston valve and the L.P., a slide valve. There is a keel condenser of about 8.6 square feet cooling surface for each engine.

The weight of each engine is 580 pounds.

Steam Launches.—Two ambulance launches have just been furnished for the army hospital-ship *Relief* by the Gas Engine & Power Co., and Chas. L. Seabury Co., Consolidated. There is a cockpit both forward and abaft the machinery space for carrying men. The principal dimensions are as follows: Length, 28 feet; beam, 8 feet; depth, 3 feet 6 inches; draught, mean, 1 foot 9 inches; draught at skeg, 2 feet 2½ inches; weight, 3,800 pounds.

The boilers are of the Seabury water-tube type, with 3.12 square feet of grate surface and 120 square feet of heating surface. The boiler casings are 30 inches long, 34 inches wide and 43 inches high, the height including the ash pan. The smoke pipes are 9 inches in diameter and 6 feet high above the tops of the boiler casings. The weight of the boiler complete is 1,274 pounds.

The engines are compound, 2¾ and 5¾ inches in diameter by 4½ inches stroke. The floor space occupied by the two engines is 15 inches wide by 22 inches long and their weight is 290 pounds. Although this type of engine is very light, it will run at full speed for a considerable length of time without adjustment or repair. This desirable quality is attained by making all the principal bearings longer than is usually done. These boats were built and delivered in exactly four weeks after signing the contract. The time allowed by the contract was five and one-half weeks, but less time was taken in order that they might be ready before the ship was ready to leave New York.

Malay.—On Saturday, June 4, the handsome new steel steam-yacht *Malay*, was successfully launched from Roach's shipyard. The new vessel is for Dr. Chas. G. Weld, of Boston,

and was designed by Gardner & Cox, of 1 Broadway, New York. The *Malay* has a water-line length of 122 feet, is 150 feet over all, 30 feet beam and 8 feet 9 inches draught. She will be schooner rigged.

On deck there is one central house, 55 feet long, in the forward end of which is a smoking room, 13 feet by 10 feet. Aft of the smoking room is the pantry, with a sink, dumb waiter and large ice chest. Then follow the engine and boiler-room skylights, on the starboard side of which is a passage way, divided off by a light steel bulkhead, with windows allowing ample ventilation in the fire and engine room, besides the regular ventilating cowls. The after 17 feet of the deck house is given up to the dining saloon, which will comfortably seat twelve persons at the table. The main staircase is at the after end of the saloon. The yacht will have a clear promenade deck aft over 48 feet long.

Below, the forecastle will have ample accommodation for eight men. Staterooms for the captain, chief engineer and steward come next on the port side, and these will each have a large berth, lockers, desk and mirror. The officers' mess is on the starboard side, opposite the officers' staterooms. Between the rooms of the chief engineer and steward is a commodious lavatory. Aft of the officers' mess is an ice chest with a capacity of three tons, and on the port side, abaft the officers' quarters, is the galley.

The owner's state room is abaft the machinery space and extends across the ship. It contains two large double berths, a spacious clothes press and two chests of drawers. Adjoining this room is a private lavatory. Following Dr. Weld's quarters is the main saloon, 16 by 11 feet, which will be handsomely fitted with divans on each side, and aft of the saloon on the starboard side are two comfortable state rooms, while on the port side there is another state room and a lavatory. Then, further aft, there is a double state room, which will be the ladies' private room. The various rooms will be finished in soft shades of enamel paint picked out in gold.

The *Malay* has triple-expansion engines of 500 I.H.P.; cylinders, 10 inches, 16 inches, 25 inches by 16 inches stroke. There are two Almy water-tube boilers, with 47 square feet of grate and

1,700 square feet of heating surface, fitted to run independently in case of an accident to one. The pumps and auxiliary machinery are all in duplicate, for the same reason. The yacht was completely furnished and equipped by the builders, having three boats—a 24-foot alco-vapor launch, an 18-foot gig and a 16-foot dingy. She has an electric-light plant for lighting the entire boat, including signal lights as well. The *Malay* has proved very successful up to date, making 15 knots on a coal consumption of 6 tons per day.

Columbia.—The steam yacht *Columbia*, designed and built by Charles L. Seabury & Co., for A. L. Pope, Hartford, Conn., was launched from their works at Morris Heights on May 21. The principal dimensions of the boat are 63 feet over all, 57 feet water-line, 12 feet beam and 4 feet 6 inches draught. She has exceptionally large cruising accommodations for a yacht of her size. The sea-going qualities have also been made a special feature in this boat. The machinery consists of a Seabury triple-expansion engine with cylinders $4\frac{1}{4}$, $6\frac{3}{4}$ and $10\frac{1}{2}$ inches by 8 inches stroke, and 425 revolutions per minute. The boiler is of Seabury's latest design, allowed a working steam pressure of 250 pounds to the square inch. The guaranteed speed of the boat is 12 miles per hour. The *Columbia* is ready to go into commission at once. Her owner is the manufacturer of the Columbia bicycle.

American.—Archibald Watt's new steel steam yacht *American* was successfully launched from the shipyard of the Jonson Engineering and Foundry Works, at the foot of East One Hundred and Eighteenth street, New York City, on June 8th. The dimensions of the new vessel are: Length over all, 254 feet; length on water line, 200 feet; moulded beam, 34 feet 6 inches, and draught, 12 feet 6 inches. The engines will develop 1,600 horse power, and will drive twin screws. There will be five Almy water-tube boilers, four of which will supply steam to the engines. These main boilers will each be 9 feet square, and will develop 3,200 horse power. The fifth, or donkey boiler, will be 5 by 8 feet, and will supply steam for the pumps, etc. The vessel will be square rigged on three masts, and is specially fitted for long voyages. The interior arrangement is admirable and the finish and decorations will be of a

costly description. There will be bilge keels placed on either side of the hull to keep the boat from rolling heavily. The entire vessel has been designed by Mr. Watt, who also superintended her construction. The *American* will be specially adapted to extended cruising.

Trinity House Yacht.—Messrs. Robert Stephenson and Co., Limited, Hebburn, launched on the 5th of May a twin-screw yacht, built for the honorable corporation of the Trinity House, London, from the designs of Mr. Frank C. Goodall, surveyor of shipping to the Trinity House. The principal dimensions of the vessel are: Length between perpendiculars, 193 feet; breadth moulded, 28 feet 2 inches, and depth moulded, 16 feet. The vessel is to serve the double duty of a yacht, used for the inspection of the light houses around the coast by the Trinity Brethren, and also as a working boat, to lift and place buoys and sinkers, &c. She is fitted with a powerful steam winch, steam windlass, steam and hand-steering gear, Westinghouse gas pump, Downton pumps, and a first-class outfit. The two sets of engines, which are of triple-expansion type, 14 inches, 23 inches and 37 inches in diameter by 24 inches stroke, with two large single-ended boilers, are also being constructed by the builders from the designs of Mr. T. Matthews, C. E., engineer-in-chief to the Trinity House, and with them the vessel is expected to develop a high rate of speed. The vessel was christened the *Vestal*.

Atmah.—The Fairfield Shipbuilding and Engineering Company, Limited, Govan, launched on the 5th of June, the twin-screw yacht *Atmah*, which they have built for Baron Edmond de Rothschild, of Paris. The dimensions of the vessel are: Length, 285 feet; breadth moulded, 34 feet; depth moulded, 21 feet 3 inches; tonnage, yacht measurement, 1,550 tons. The hull is of steel, with side-bar keel and bilge keels, clipper stem and elliptical stern, topgallant forecastle and raised quarter deck. The bottom of the vessel is of the semi-longitudinal character of construction, with an inner bottom fitted under the main coal bunkers, forming water-ballast tanks for a length of about 50 feet. There are seven water-tight bulkheads throughout the ship. On the shade deck provision is made for carrying several quick-firing

guns. The machinery consists of two sets of triple-expansion engines, each set having four cranks and four cylinders, there being one high-pressure, one medium-pressure and two low-pressure cylinders. Steam is supplied by two single-ended boilers, each having four furnaces, and arranged with one funnel. The working pressure is 160 pounds, and each boiler will be fitted with Quiggins' internal feed heater. The yacht will be rigged as a two-masted schooner, with a square sail on the fore mast.

Cochno.—The Clydebank Engineering and Shipbuilding Company, Limited, launched from their yard, on the 6th of June, a handsome steam yacht, which they have built from their designs for Mr. W. A. Donaldson, of Cochno, the chairman of the company. Her principal dimensions are: Length between perpendiculars, 185 feet; length over figurehead and taffrail, 217 feet; breadth moulded, 26 feet 6 inches; depth, 14 feet 6 inches. Her tonnage, by the Thames rule, is 606 tons. The vessel has a most graceful appearance, and will be fore-and-aft rigged, with two pole masts. There is a promenade deck amidships, extending the full breadth of the vessel and for about 90 feet in length. The yacht will be lighted throughout by electricity, for which purpose a battery of accumulators has been provided, in addition to the usual dynamo and engine equipment. A powerful search-light will also be fitted on board. The machinery, which is also being supplied by the builders, is of the inverted triple-expansion type, with a single-ended return-tube boiler, all of sufficient power to drive the vessel at a high rate of speed.

Princess Alice.—The steam yacht of this name, recently built for the Prince of Monaco, by Laird Brothers, of Birkenhead, ran off her contract trial on the 30th of April, when a mean speed of 13 knots was obtained for four hours.

The *Princess Alice* is of 1,270 tons register, 225 feet long, 34 feet beam and 20 feet depth of hold.

Daimler.—The new twin-screw Daimler motor-launch *Daimler*, went down the Firth of Clyde on her trial trip on the 7th of May. The *Daimler* has been built by Messrs. Paul Jones and Son, Greenock, to the design of Messrs. J. and H. M. Paterson, Green-

ock. She is a boat 58 feet long, 9 feet 8 inches broad and 5 feet 4 inches deep, built of elm, teakwood and pitch pine, with elm and oak framing; she is schooner rigged. The motors are placed amidships, about 8 feet space being occupied, and oil sufficient to drive the boat 1,000 miles is also stored here. Next comes the lavatory and saloon, the latter being handsomely upholstered in Utrecht velvet, and occupying 13 feet 6 inches. Behind this there is a 10-foot cockpit. The motors are supplied by the owners, the Daimler Motor Company, Limited, and are nominally 10-horse power each. They are practically the same as those fitted to motor cars. It is claimed that the cost per horse power per hour is 1 pound of benzine, costing 11d. per gallon in London. Notwithstanding the choppy nature of the water, the boat had no difficulty in reaching 9 knots—a most satisfactory performance.

Osceola.—The *Osceola* is a wooden steam yacht, built by Samuel H. Pine for Thomas L. Watt, of New York, and launched from his yard, foot of Twenty-fifth street, Brooklyn, March 9th. The vessel was designed by Gustav Hillman, 470 Greene avenue, Brooklyn, and has the following principal dimensions, viz: 129 feet in length on deck and 115 feet on W.L.; 18 feet extreme beam, 9 feet 10 inches depth of hold, and about 7 feet 6 inches draught. The hull is built entirely of wood, with the exception of the engine and boiler bulkheads and coal bunkers, which are of $\frac{3}{16}$-inch steel plate stiffened by 2-inch by 2-inch angles and tees. The construction is strong, of first-class material and thoroughly put together in every respect, and her shape beautifully fair. Keel, stem, post, etc., of white oak; keelsons and deadwood of yellow pine, all proportionately heavy; has double diagonal yellow-pine ceiling, two streaks of clamps and bilge streaks, forming upper and lower ties, besides oak streaks. Deck frame and deck of yellow pine, the latter all laid comb grain and perfectly clear. Outside planking also of yellow pine; bulwark stanchions of locust, main rail of white oak, netting rail of mahogany.

She carries very heavy ground tackle, which is handled by a steam windlass. Large deck house forward, finished in white

pine and mahogany; has dining room in after end and steering room in forward end; large trunk house over engine and boiler with sliding sash all round, and a large skylight over engine gives ample means for light and air. Quarters forward for crew are roomy and well ventilated; large galley with skylight; fine ice house; state rooms for captain and engineer; mess room, and forecastle with seats and eight swinging berths; also toilet room.

Owner's cabin is entered by a large trunk with companion slide; on each side of stairs an extra state room; main cabin with wide sofas to afford sleeping accommodation for four persons, sides fitted up with ample lockers, and combined desk and book shelves on one side and a sideboard on the other; a mantel shelf with mirror above in forward end between state-room doors. Forward of cabin there are on each side two large state rooms and a toilet room, fitted up with wide berths, wardrobes and lockers, drawers under berths, large marble wash basins and Bishop's patent water closets in toilet rooms.

Cabin and state rooms are finished in white pine; berth fronts, mantel, sofa fronts and trimmings, sideboard and desk are in quartered white oak. Skylights over state rooms and cabin, companion slide and trunk are all built of mahogany and extra large. All the joinerwork has been done by Henry Guion, 735 to 739 East Ninth street, New York. The painting and decorating was done by David Clark & Son, Third avenue and Twenty-Sixth street, Brooklyn. The cabin and state rooms are all kept in white, tinted panels with stencil decorations, enamel finish and gilded lines.

The engines and machinery have been furnished by John W. Sullivan, 384 and 385 South St., New York, very substantially built, and consisting of a plain compound engine with cylinders 15 and 27 inches diameter and a stroke of 20 inches, with a copper keel condenser, and driving a 6-foot propeller. The boiler is of the Scotch type, to carry a working pressure of 175 pounds steam, and was built by Christopher Cunningham & Son, Brooklyn, N. Y., in strict accordance with the following specifications: Dimensions—diameter, 10 feet; length, 10 feet; thickness of shell, $\frac{15}{16}$ inch; back and front heads, $\frac{5}{8}$ and $\frac{3}{4}$ inch; tube plate, back, $\frac{5}{8}$ inch; furnace head, back, $\frac{5}{8}$ inch; back connection head,

$\frac{5}{8}$ inch; back connection strap, $\frac{9}{16}$ inch; brace bolts (up-set ends), $2\frac{5}{8}$ inches; crown bolts, $1\frac{1}{2}$ inches; stay bolts, $1\frac{1}{4}$ inches; manhole frames and plates, wrought steel. Furnaces: Two Fox corrugated furnaces, 37 inches inside diameter, 41 inches outside diameter, 6 feet 10 inches long, $\frac{1}{2}$ inch thick. Tubes: 140, best American lap-welded charcoal-iron tubes, 3 inches diameter, 6 feet 6 inches long. Crown bars: $\frac{3}{4}$ inch by 10 inches wide, wrought iron construction. Boiler built of best marine steel throughout, and butt strapped inside and out on horizontal seams, double riveted on circumferential seams.—"American Shipbuilder."

Niagara.—The following valuable information has been kindly contributed by T. Jackson Shaw, Esq., Superintending Engineer of the Harlan and Hollingsworth Co., in a letter to the editor.

I would like, for the benefit of the readers of the JOURNAL, to give what may be interesting data on three trials of the twin-screw steam yacht *Niagara*, built by the Harlan and Hollingsworth Co. for Howard Gould.

The dimensions of the yacht are as follows: Length between perpendiculars, 247 feet 6 inches; beam, 36 feet; depth to the spar deck, 28 feet 2 inches.

On trial our draught of water was 17 feet aft and 15 feet 9 inches forward. The total displacement was 2,240 net tons. This weight included 400 gross tons of coal, 15,000 gallons of water in tanks, and all stores and outfit on board. The yacht is designed with the Lundborg shaft carriers instead of struts.

After careful consideration as to the direction to run the engines—as to turning the wheels inboard at the top or outboard, and making inquiry from different sources on this subject—also having learned that the British Admiralty were building battleships on the other side with tops of the wheels turning inboard, I concluded to follow out the same on the *Niagara*.

The engines are of the triple-expansion type, having three cylinders, 18 inches, 28 inches, 45 inches by 30 inches stroke. Boilers, three in number, Scotch type, having a total of 204 square feet of grate, and built for a working pressure of 160 pounds per square inch.

We burned on the trials good quality of hard coal with natural draft, she having no appliances for forced draft.

The first wheels were 10 feet in diameter, 13 feet pitch, having a Griffith-shape blade.

The result of the first trial was as follows:

The average revolutions of the engines, 128; average steam pressure, 156; average speed, 12.54 knots; the course being from Scotland Light Ship to Barnegat. The slip of the wheels, you will see, was 23.6 per cent.

After thinking over the matter, I concluded in my own mind that the Lundborg extensions prevented the water from getting to the wheels properly, and I decided to increase the diameter of the wheels 6 inches, increase the blade area on the points, and increase also the pitch to 14 feet. This was done, the ship docked, and the new blades put on, but no change was made as to turning the engines in the opposite direction. With this change in the wheels, over the same course, the ship on the same draught, we made an average speed of 12.8 knots on an average revolution of 126, showing the slip to be in this case 26.4 per cent.

After this trial I immediately decided to run the wheels in the opposite direction, the guides of the engines being of such design that this could be done very readily. I therefore docked the ship, put the starboard wheel on the port engine and the port wheel on the starboard engine, with the result on trial on August 16, the ship being still in the same condition of draft, etc., as follows:

Our average speed was 14.12 knots, our average revolutions being 118, which gave a slip of 13.3 per cent.

We did not indicate the engines on any of these trials, so that I can give you no data as to H.P., other than I should assume that we were developing on the first trial about 2,200 H.P., on the second trial about 2,100 H.P., and on the third trial about 1,950 H.P.

The keel is carried straight back to the rudder pintal in the usual way, and there is no well or opening through the deadwood abreast of the wheels.

OBITUARY.

CHARLES EDWARD EMERY, Ph. D.

Dr. Emery, who died at his home in Brooklyn, N. Y., in June last, began his nearly two score years of professional life in the Engineer Corps of the Navy. Among the many who, once members of that Corps, have gained distinction in the pursuits of civil life, he was in the front rank, and marine engineers knew him better than any of the others, because of his having continued work in line with them for most of his years. He entered the Navy early in the period of the civil war, was in Farragut's fleet during the operations on the lower Mississippi that ended in the capture of New Orleans, and afterward in the attacks on Vicksburg and Port Hudson. After the completion of his tour of duty afloat, he, under direction of Mr. Isherwood, then Engineer-in-chief, conducted a long series of experiments at the Novelty Works, New York City, to determine the limit of economy in the expansion of steam. Resigning from the service in 1869, he continued this experimental work in the interest of the establishment in which it was carried on. The results were afterward published by Prof. W. P. Trowbridge.

The intelligent manner in which he conducted these experiments, established his reputation and brought to him the appointment of General Superintendent of the American Institute Fair, in the year of his resignation.

Here he instituted a system for boiler and engine tests, under which such tests were carried on through several successive exhibitions of the Institute. Shortly after this he was appointed Consulting Engineer of the U. S. Coast Survey, his first work being the design and construction of the *Hassler*. Her engine was the pioneer in this country of the compound-engine period. From the performance of this engine and those of other ships subsequently constructed for the Coast Survey, he collected a

large amount of data, which he published in full, with a discussion of the results.

His duties having been extended by the Treasury Department to include the vessels of the Revenue Marine Service, he designed the machinery of four ships for that service. Each vessel's engine differed from the others in the manner of the use of steam in the cylinders.

With a colleague from the Engineer Corps of the Navy he, in 1874, conducted an exhaustive series of tests, with the machinery of these ships, for the purpose of determining the relative economy of the simple and compound systems, concerning which there was then a wide difference of opinion. The report of the results of these tests, when published, was favorably received by engineers, and generally accepted as conclusive.

Dr. Emery retained his connection with these services until 1891. Previous to his entering the Navy he had studied law for two years, with a view of taking up patent practice, for which and as a consulting engineer he opened an office in New York City in 1869. In 1876 he was made one of the judges of the Philadelphia Centennial Exposition, and the report of these judges, for Group XX, which included the results of engine and boiler tests made there, was largely his work, and was a valuable contribution to the literature of the steam engine.

It was as Chief Engineer and afterward as Manager of the New York Steam Company, that Dr. Emery undertook his most important work, which was the installation of a plant for the underground distribution of steam over large districts, for heating and power purposes. It had a boiler capacity of sixteen thousand horse power, and its main lines were nearly five miles in length. Many mechanical difficulties were overcome in its construction by his ingenuity and fertility of resource. It is still in use. His description of it, in a paper read before the British Institution of Civil Engineers in 1889, won for him the Watt medal and the Telford premium. The degree of Doctor of Philosophy was conferred on him by the University of New York in 1879. He was for several years and up to his death a non-resident professor of Cornell University. He was for some time Consulting Engineer

of the New York and Brooklyn Bridge, particularly in the matter of its terminal facilities.

Dr. Emery found a part of his recreations in his connection with the Brooklyn Institute of Arts and Sciences, of which he was a Fellow, and before which he delivered several lectures on engineering subjects.

In the latter years of his life his consulting practice has been of a widely varying character, the most important of it being connected with litigation in patent cases, and those arising from controversies regarding water power. He was an active member of the Societies of Civil, Mechanical, Mining and Electrical Engineers, of the American Society of Naval Engineers, and the Society of Naval Architects and Marine Engineers; a member of the American Society for the Advancement of Science, of the British Institution of Civil Engineers, and also of the Engineers' Club of New York. In 1884 he was appointed on a committee of the American Society of Mechanical Engineers, to prepare a code for steam boiler trials, and in 1895 was chairman of a committee to revise this code, and was engaged in the preparation of its report at the time of his death.

This by no means exhaustive record of Dr. Emery's accomplishments makes manifest not only the magnitude of his work, but the wide field in the art and science of Engineering it covered, as well as the persevering industry and assiduity of his life. Without the advantage of a strictly technical education in his youth, he mastered the theory and practice of his profession, and the success he attained may be truthfully attributed to the genius of hard work. He will be much missed in the technical societies of which he was a member, at the meetings of which he took frequent part in the proceedings.

He was fluent in speech, ready in debate, full of the spirit of his subject, and orderly and systematic in the arrangement of what he had to say. Dr. Emery retained many pleasant recollections of his service in the Navy, and continued many friendships contracted therein. He appreciated fully the value to his after life of the systematic training it subjected him to in the plastic days of his youth.

He was in his sixtieth year at the time of his death. He left a widow, and a son in man's estate.

JOHN F. PANKHURST.

Mr. John F. Pankhurst, who died in Cleveland, June 2d, 1898, was born at Cleveland, Cuyahoga Co., Ohio, March 28th, 1838. He received an education in the Cleveland schools, and at the age of seventeen took a special course in Engineering and Mechanics, subsequently following that line of business as a trade, continuing his studies in the evenings. This plan of study was continued for five years; he then spent five months as an assistant engineer on a lake steamer and several months as engineer, as he had expected to become a marine engineer.

In 1865, Mr. Pankhurst, in connection with Robert Wallace, opened a small machine shop, under the firm name of Wallace, Pankhurst & Co., and three years later the Globe Iron Works was purchased by them, and the partnership then formed continued until 1886, when it was reorganized and incorporated, with a capital stock of $500,000.00, with H. M. Hanna as President, Jno. F. Pankhurst as Vice-President and General Manager, and Luther Allen as Secretary and Treasurer.

In the development of shipbuilding on the Great Lakes, Mr. Pankhurst was an important figure. His early education, experience and clear judgment, together with his natural bent for shipbuilding and marine engineering, fitted him for the eminent position which he held, and, by strict application to the business before him, he succeeded in building up a large and profitable shipbuilding and marine engineering plant, known as the Globe Iron Works Company.

Mr. Pankhurst was favorably known all over the United States, through his connection with the above-named Company, and Cleveland attained her prominent position as an iron and steel shipbuilding port very largely through the energy and industry of Mr. Pankhurst and those pioneers in the industry who were associated with him.

At the plant of the Globe Iron Works Co., under Mr. Pankhurst's management, light-house tenders and revenue cutters have been built for the U. S. Government. The twin-screw steamer *Virginia* and the twin-screw, exclusively passenger vessels, *North-West* and *North-Land*, as well as many of the largest of the new type of steel cargo vessels, were built under his supervision. Since the reorganization of this Company in 1886, there have been built thirty-four ore, grain and package freight carriers, three high-powered passenger vessels, two light-house tenders, one steam yacht and one revenue cutter; making a total of forty-one vessels built under Mr. Pankhurst's direct management.

It may be said of Mr. Pankhurst that he died in the harness, although he had to give up the active management of the great shipbuilding industry, to which he had devoted the best years of his life, some months before he died. He was keenly alive to, and greatly interested in, all things pertaining to the progress and future of the merchant marine on the Great Lakes and elsewhere, and it is to be regretted that he was not spared a few years longer to enjoy the fruits of his labor and to note the rapid progress in the science of marine engineering, in which he had been so actively engaged for more than thirty years and in which he occupied so eminent a position.

Mr. Pankhurst was also greatly interested in the growth and development of his home city, and took an active part in municipal and financial affairs. He was for several years an active member of the Cleveland Chamber of Commerce and of the Cleveland Park Commission, and was also Vice-President of the Forest City Savings Bank.

In Mr. Pankhurst's death the city of Cleveland, as well as his business associates, lost one of its most active and influential men.

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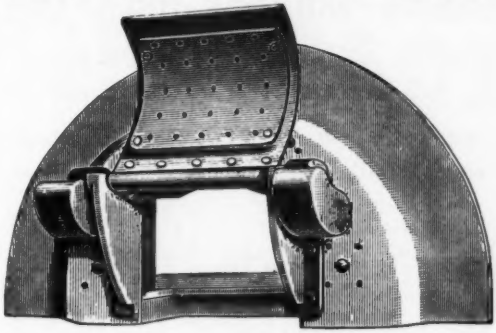

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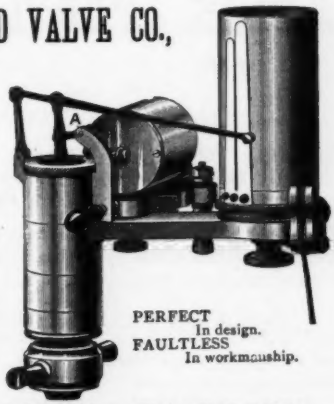

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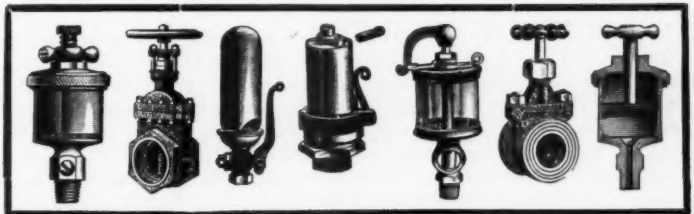

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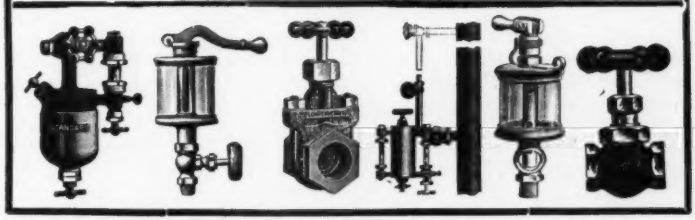

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